

Radiation Data and Reports

VOLUME 15, NUMBER 5

MAY 1974

(Pages 227-308)

RDDRA 15(5) 227-308 (1974)



U.S. ENVIRONMENTAL PROTECTION AGENCY

Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tēr'a
10^9	giga	G	jī'ga
10^6	mega	M	még'a
10^3	kilo	k	kī'lo
10^2	hecto	h	hēk'to
10	deka	da	dēk'a
10^{-1}	deci	d	dēs'i
10^{-2}	centi	c	sēn'ti
10^{-3}	milli	m	mī'l'i
10^{-6}	micro	μ	mī'kro
10^{-9}	nano	n	nān'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fēm'to
10^{-18}	atto	a	āt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
A	ampere(a)	
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps = 2.22×10^{11} dpm
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-13} ergs
g	gram(s)	3.527×10^{-3} ounces = 2.205×10^{-3} pounds
Hz	hertz	cycle per second
kVp	kilovolt peak	
m	meter(s)	39.4 inches = 3.28 feet
m ³	cubic meter(s)	
mCi/mi ²	millicuries per square mile	0.386 nCi/m ² (mCi/km ²)
mi	mile(s)	
ml	milliliter(s)	
nCi/m ²	nanocuries per square meter	2.59 mCi/mi ²
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g
r/min	revolutions per minute	
s	second	
yr	year	

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RADIATION DATA AND REPORTS

Volume 15, Number 5, May 1974

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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RADIATION DATA AND REPORTS

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U.S. ENVIRONMENTAL PROTECTION AGENCY

Russell E. Train, Administrator

Environmental and Radiological Monitoring at the National Reactor Testing Station During FY-1973 (July 1972-June 1973)

O. Doyle Markham¹

The routine environmental monitoring program at the National Reactor Testing Station (NRTS) during FY-1973 is described. In addition to the measurement of direct radiation exposures in the environment, the concentrations of radioactivity in air, groundwater, and milk also are determined. The results of a soil sampling program are discussed. The data from onsite and nearby community sampling locations are compared to background concentrations and the applicable standards established by the U.S. Atomic Energy Commission.

In addition, several special ecological monitoring programs have been designed to assess the effect of NRTS operations on the environment. One of the ecological studies quantifies the level of radioactivity in antelope tissues collected on and near the NRTS. An investigation to ascertain the ratio of iodine-129 to stable iodine-127 in the NRTS environs also is described.

This report describes results of the environmental monitoring program conducted by the Health Services Laboratory at the National Reactor Testing Station (NRTS). The Health Services Laboratory (HSL) is a division of the Idaho Operations Office, U.S. Atomic Energy Commission (AEC).

The National Reactor Testing Station is located in the upper Snake River Plain in southeastern Idaho. The station consists of 571 800 acres (approximately 2286 km² or 893 square miles) which extends almost 63 km (39 miles) north to south and about 58 km (36 miles) east to west at its broader southern part. The reservation includes portions of Butte, Bingham, Bonneville, Jefferson and Clark Counties. Several small communities are situated adjacent to the boundaries of NRTS (figure 1). Arco, the largest of these with a 1970 population of 1244 is 11 km (7 miles) west of the site boundary. Located near the northwestern border is Howe, with Mud Lake and Terreton to the northeast. The largest town in the area, Idaho Falls, with a population of approximately

36 000 is 47 km (29 miles) east of the site boundary.

The upper Snake River Plain is representative of the cool desert shrub biome. Sagebrush-grass communities are dominant on the site but other vegetative communities are important locally. Associated with the various vegetative types is a varied animal component, encompassing most of the reptiles, birds, and mammals associated with this biome.

Most of the land surrounding the site boundary is undeveloped. This land, as well as portions of the site, is utilized for sheep and cattle grazing. Most of the nearby farming is concentrated in areas north and northeast of the station. Larger farming areas are situated at a greater distance from the NRTS in the Snake River Valley.

The NRTS was established in 1949 to provide a location where the AEC could build, test, and operate various types of nuclear reactors and allied plants and equipment. Since that time, 50 reactors have been constructed at the NRTS. Sixteen of these reactors presently are operating or capable of operating. Table 1 and figure 1 indicate acronyms and locations for the various NRTS facilities.

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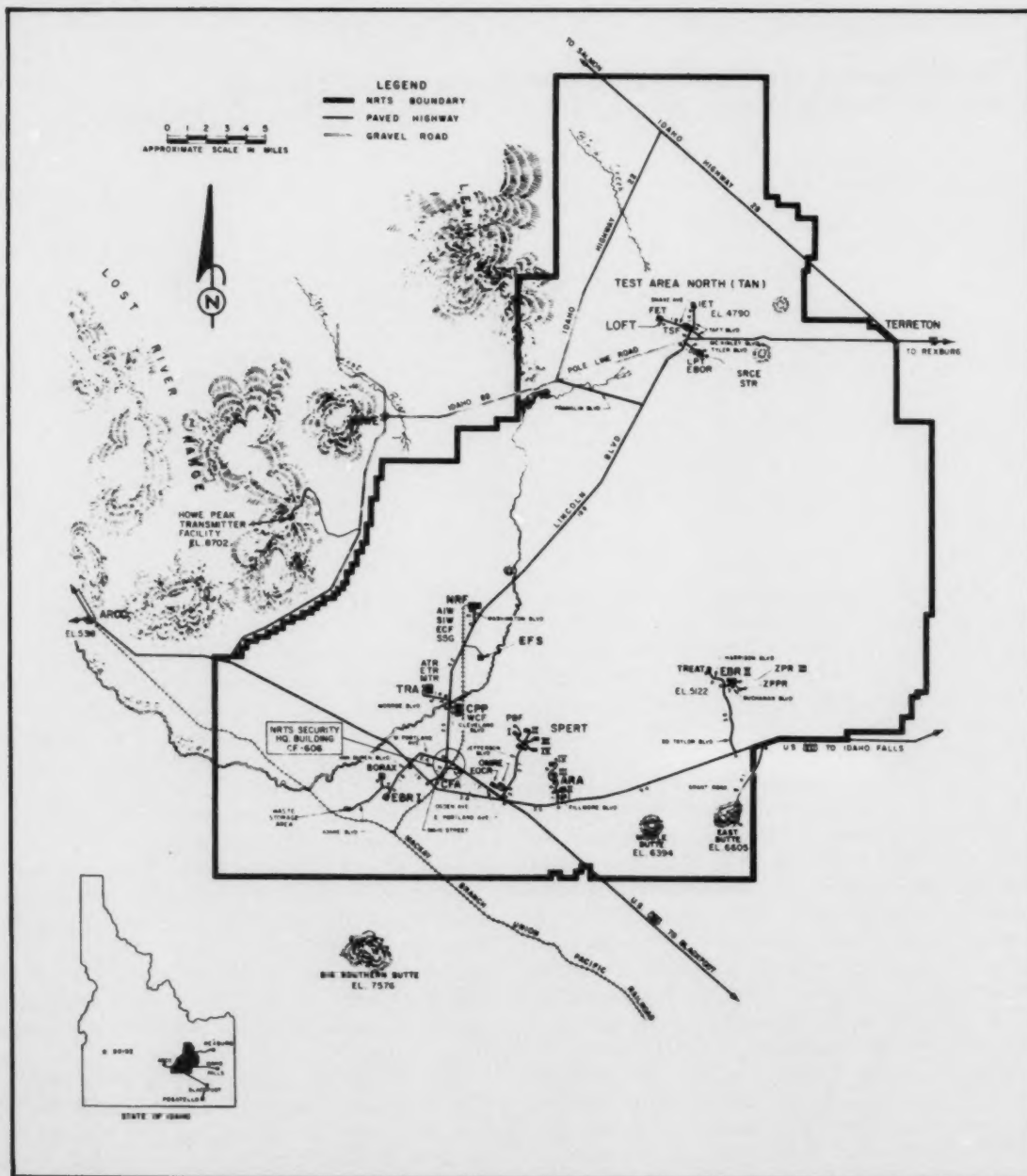


Table 1. Tabulation of facilities at the NRTS

Reactors operating or operable		Abbreviation
1. Engineering Test Reactor.....		ETR
2. Experimental Breeder Reactor No. 2.....		EBR-II
3. Large Ship Reactor "A".....		A1W-(A)
4. Large Ship Reactor "B".....		A1W-(B)
5. Submarine Thermal Reactor.....		SIW-(STR)
6. Transient Reactor Test Facility.....		TREAT
7. Argonne Fast Source Reactor.....		AFSR
8. Engineering Test Reactor Critical *.....		ETRC
9. Advanced Reactivity Measurement Facility No. 1.....		ARMF-I
10. Advanced Test Reactor Critical *.....		ATRC
11. Natural Circulation Reactor.....		S6G
12. Advanced Test Reactor.....		ATR
13. Split Table Reactor *.....		STR
14. Coupled Fast Reactor Measurement Facility *.....		CFRMF
15. Zero Power Plutonium Reactor *.....		ZPPR
16. Power Burst Facility.....		PBF
Reactors dismantled, transferred, or in standby status		
1. Boiling Water Reactor No. 1.....		BORAX-I
2. Boiling Water Reactor No. 2.....		BORAX-II
3. Boiling Water Reactor No. 3.....		BORAX-III
4. Boiling Water Reactor No. 4.....		BORAX-IV
5. Heat Transfer Reactor Experiment No. 1.....		HTRE-I
6. Heat Transfer Reactor Experiment No. 2.....		HTRE-II
7. Heat Transfer Reactor Experiment No. 3.....		HTRE-III
8. Shield Test Pool Facility Reactor *.....		SUSIE
9. Critical Experiment Tank *.....		CET
10. Hot Critical Experiment *.....		HOTCE
11. Stationary Low Power Reactor No. 1 ^b		SL-1
12. Reactivity Measurement Facility *.....		RMF
13. Gas Cooled Reactor Experiment.....		GCRE
14. Organic Moderated Reactor Experiment.....		OMRE
15. Experimental Organic Cooled Reactor (mothballed before startup).....		EOCR
16. Experimental Breeder Reactor No. 1.....		EBR-I
17. SNAP 10A Transient No. 3.....		SNAPTRAN-3
18. Special Power Excursion Reactor Test No. 1.....		SPERT-I
19. Boiling Water Reactor No. 5.....		BORAX-V
20. High Temperature Marine Propulsion Reactor *.....		630-A
21. SNAP 10A Transient No. 1.....		SNAPTRAN-1
22. Mobile Low Power Reactor No. 1 (Army).....		ML-1
23. SNAP 10A Transient No. 2.....		SNAPTRAN-2
24. Experimental Beryllium Oxide Reactor.....		EBOR
25. Fast Spectrum Refractory Metals Reactor.....		710
26. Advanced Reactivity Measurement Facility No. 2.....		ARMF-II
27. Materials Test Reactor.....		MTR
28. Special Power Excursion Reactor Test No. 2.....		SPERT-II
29. Special Power Excursion Reactor Test No. 3.....		SPERT-III
30. Special Power Excursion Reactor Test No. 4.....		SPERT-IV
31. Zero Power Reactor No. 3 *.....		ZPR-III
32. Cavity Reactor Critical Experiment *.....		CRCE
33. Nuclear Effects Reactor *.....		FRAN
34. Spherical Cavity Reactor Critical Experiment.....		SCRCE
Other facilities in use		
1. Auxiliary Reactor Area.....		ARA
2. Idaho Chemical Processing Plant.....		ICPP
3. Expanded Core Facility.....		ECF
4. Fuel Element Storage Facility.....		FESF
5. Gamma Irradiation Facility.....		GIF
6. Health Services Laboratory.....		HSL
7. Chemical Engineering Laboratory.....		CEL
8. Waste Calcining Facility.....		WCF
9. Field Engineering (formerly Flight Engine Test) Facility.....		FET
10. Low Power Test Facility.....		LPTF
11. Test Area North.....		TAN
12. Technical Services Center (CF-688-689).....		TSC
13. Central Facilities Area.....		CFA
14. Naval Reactor Facility.....		NRF
15. Test Reactor Area.....		TRA
16. Technical Services Facility.....		TSF
17. Experimental Field Station.....		EFS
18. Hot Pilot Plant.....		HPP
19. Shield Test Pool Facility (adapted for EBOR).....		STPF
20. Gas Cooled Reactor Facility.....		GCRF
21. Reactor Training Facility.....		RTF
22. Computer Science Center (in Idaho Falls).....		CSC
23. Fuels and Examination Facility.....		FEF
24. Radioactive Storage Area.....		RSA
25. Hot Fuel Examination Facility.....		HFEF
26. Initial Engineering Test Facility.....		IET
Reactors under construction		
1. Loss-of-Fluid Test Facility.....		LOFT

* Zero or low power reactor.

^b Accidentally destroyed during shutdown, January 3, 1961, following 931.5 megawatt days of successful operation.

Currently, emphasis is placed on several major programs. One program provides test irradiation services from two high-flux reactors, the Engineering Test Reactor (ETR) and Advanced Test Reactor (ATR). The Idaho Chemical Processing Plant (ICPP) recovers uranium from highly enriched spent fuels and solidifies and stores the resultant radioactive waste. The Loss-of-Fluid Test (LOFT) and the Power Burst Facility (PBF) are major projects in the light-water-cooled reactor safety program. The Experimental Breeder Reactor II (EBR-II) is the only operating Liquid Metal Fast Breeder Reactor in the United States. Other significant programs include the operation of the Naval Reactor Facility (NRF) and storage at the Radioactive Storage Area of fission and activation waste from the NRTS and transuranic waste from the Commission's Rocky Flats activities.

Along with the routine monitoring program (external radiation, soil, water, air, milk, and wheat) conducted by the Health Services Laboratory, the U.S. Geological Survey (USGS) monitors the aquifer through periodic sampling of wells on and near the NRTS. In addition, several special studies have begun under a recently initiated NRTS radioecology program. This program provides both one-time and continuous studies of the ultimate fate of radioactive pollutants in the environs.

Atmospheric monitoring

The atmospheric monitoring program provides specific radionuclide identification and surveillance of the gross alpha, gross beta and strontium-90 in air at onsite, boundary and distant background sampling locations.

At each of eight onsite, six boundary, and three background locations (figure 2), continuous air samplers maintain an average air flow of approximately 28 liters/minute through a set of filters. A membrane particle prefilter (Gelman Model AN-800) is followed by an activated charcoal-impregnated cellulose fiber filter (Gelman Model AC-1) for radioiodine collection. In order to permit the short-lived radon and thoron daughters to decay, the filters are analyzed a minimum of 5 days after com-

pletion of each 1-week sampling period. The membrane filter is analyzed for gross alpha and gross beta activity and the AC-1 filter is analyzed for gross beta activity. All analyses utilize low background counting systems. All activity detected on the AC-1 filters is assumed to be iodine-131. Each quarter, composite particulate filters from each of several selected locations are analyzed for gamma-emitting nuclides by gamma spectrometry and for strontium-90 by wet chemistry methods. Gross alpha activity analysis was discontinued after FY-1973 and has been replaced by analysis for specific alpha emitters using wet chemistry and alpha spectrometry. In addition to the 17 weekly air samplers, filters on two high volume air samplers are changed each work day. Each of these daily samplers is equipped with a 4-inch diameter BM-2133 cellulose fiber filter impregnated with charcoal. These samplers located at CFA and EFS draw an average of 1230 liters of air per minute through the filters. These two samplers provide an early warning of any significant release. The filters are gross gamma counted immediately after collection and periodically during the first 24 hours after collection to observe the radioactive decay rate of the collected radioactivity. Decay rates slower than those expected for the naturally occurring radon and thoron daughters indicate that other nuclides were collected and additional analyses are performed to evaluate specific radionuclide concentrations in the sampled air. The gross gamma analysis is used for daily checking of activity levels in the atmosphere and is not intended to provide a permanent record of airborne radioactivity.

Starting in mid-February 1973, tritium sampling in the atmosphere began at the EFS and at another location on Lincoln Boulevard approximately 2 km south of ICPP (figure 1). Water vapor is collected as air is pumped through a silica gel desiccant at a rate of 0.28 liters/min. After each 2-week collection period, the silica gel is heated in the laboratory, and the resultant water vapor is condensed and analyzed for tritium in a liquid scintillation counter.

The maximum tritiated moisture concentrations were 24 pCi/m³ of air at the EFS and

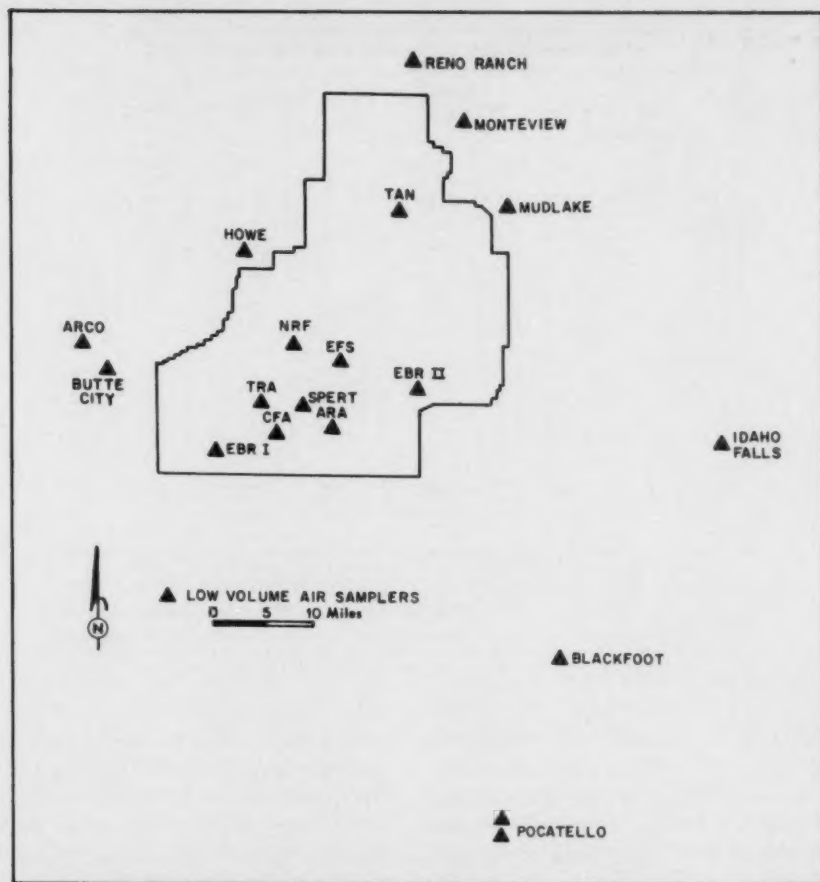


Figure 2. NRTS onsite and offsite air monitoring network (EFS monitoring station installed late in FY 1973)

44 pCi/m³ of air at Lincoln Boulevard station. The average concentration for both sampling stations was less than 11 pCi/m³. The highest was 2.2×10^{-2} percent of the AEC concentration guide value of 200 nCi/m³ for an individual in an uncontrolled area (1).

The gross alpha, gross beta, and iodine-131 determinations for the air monitoring stations are summarized in table 2. The average gross alpha concentrations were 1.7 fCi/m³ for the six boundary stations and 1.6 fCi/m³ for the eight onsite stations. Due to the release of naturally occurring alpha emitters as a result of fossil fuel combustion from fertilizer manufacturing processes, the gross alpha concentrations at the background locations of Idaho Falls,

Blackfoot, and Pocatello were not representative of the NRTS background; therefore, a comparison to background levels is not attempted. However, if significant onsite releases of alpha activity were occurring, gross alpha air concentrations for at least one and most likely several of the onsite stations would be higher than the concentrations in the boundary communities. Since this was not observed, it is concluded that the gross alpha concentrations measured at the onsite and boundary stations did not result from NRTS related activities.

The average gross beta concentrations were 110 fCi/m³ for onsite stations, 100 fCi/m³ for boundary communities and 100 fCi/m³ for background stations. The highest onsite aver-

Table 2. Summary of atmospheric monitoring in the vicinity of the National Reactor Testing Station during FY-1973

Sampling location	Gross alpha concentration ^a (fCi/m ³)		Gross beta concentration ^b (fCi/m ³)		Iodine-131 concentration ^c (fCi/m ³)	
	Maximum	Average	Maximum	Average	Maximum	Average
Onsite:						
EBR-I	3.1	1.4 ± 0.5	1 040	130 ± 160	21	<10
CFA	2.3	1.5 ± .5	580	120 ± 120	22	<10
TRA	3.9	1.7 ± .7	540	120 ± 110	76	<10
NRF	2.6	1.5 ± .6	490	100 ± 100	38	<10
TAN	3.1	1.5 ± .6	420	100 ± 90	25	<10
SPERT	4.0	1.5 ± .6	530	100 ± 110	33	<10
ARA-II	3.6	1.4 ± .5	410	90 ± 70	13	<10
EBR-II	4.0	1.7 ± .7	460	100 ± 90	18	<10
Boundary:						
Mud Lake	7.8	1.9 ± .9	580	110 ± 110	13	<10
Howe	3.6	1.7 ± .7	450	100 ± 100	26	<10
Butte City	3.1	1.5 ± .5	500	100 ± 100	10	<10
Reno Ranch	3.2	1.4 ± .6	500	100 ± 100	32	<10
Arco	3.8	1.7 ± .7	460	100 ± 90	23	<10
Montevideo	3.6	1.6 ± .6	340	80 ± 70	54	<10
Background: ^d						
Blackfoot	3.9	2.3 ± .8	490	100 ± 100	10	<10
Idaho Falls	4.8	2.5 ± .8	410	90 ± 80	23	<10
Pocatello	81.1	16.8 ± 15.0	470	100 ± 90	29	<10

^a The AEC concentration guide value (1) for gross alpha exposure to an individual in an uncontrolled area is 20 fCi/m³ of air.

^b The AEC concentration guide value (1) for gross beta exposure to an individual in an uncontrolled area is 1000 fCi/m³ of air.

^c The AEC concentration guide value (1) for iodine-131 exposure to an individual in an uncontrolled area is 100 pCi/m³ of air.

^d Gross alpha concentrations at these locations are not representative of the NRTS background due to the presence of the naturally occurring nuclide, polonium-210, released by the burning of fossil fuels and other industrial activity. The concentration guide value for polonium-210 for the general population is 2 pCi/m³.

age concentrations measured, 130 fCi/m³ at EBR-I, was well below the guide value of 1 pCi/m³ for an individual in an uncontrolled area. The highest average boundary concentration, measured at Mud Lake, was lower than the guide value.

Although the overall onsite average was only slightly above the background average, several onsite stations had average concentrations above the background average of 100 fCi/m³. The highest average concentration at an onsite station, EBR-I, was 36 percent above the background level. (EBR-I is not an operating facility, but is in a predominant downwind direction from the ICPP.) These higher average values for onsite stations were the result of atmospheric releases by NRTS facilities, primarily the ICPP. During FY-1973, over 99 percent of the long-lived particulate activity released to the atmosphere from NRTS facilities originated from the ICPP (2).

The weekly gross beta concentration data for EBR-I and the average of the weekly data from the background stations (Blackfoot, Pocatello, Idaho Falls) were compared by a

two factor analysis of variance with weekly periods and the two sampling stations (EBR-I and background average) as sources of variation. The analysis indicated statistically significant effects due to sampling period ($\alpha < 0.005$) and sampling stations ($\alpha = 0.025$). When the highest boundary location, Mud Lake, was compared in a similar analysis to offsite averages, the station effect was not a significant contribution to the variability ($F = 1.3$; $DF = 1, 51$). However, the weekly sampling periods did contribute significantly to the variability ($\alpha < 0.005$). This would indicate that the gross beta air concentrations at EBR-I were significantly higher than background due to NRTS atmospheric releases of radioactivity, but the gross beta air concentrations at Mud Lake were not different from background concentrations. The analysis also indicates that the variability of the data is related to the weekly sampling periods. This weekly variability is related to variability in worldwide fallout and also to seasonal and weather conditions.

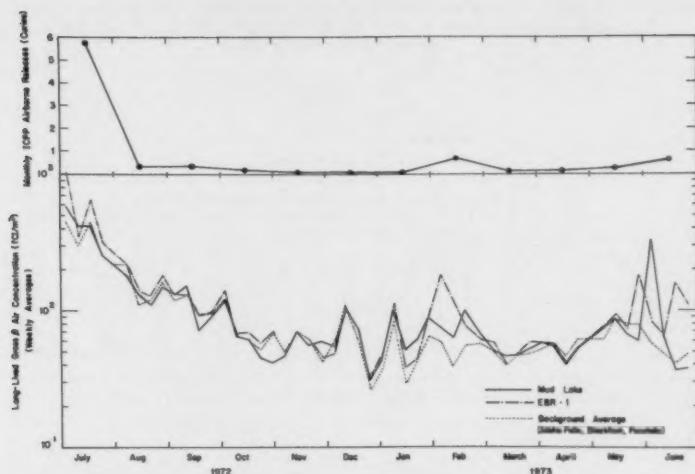


Figure 3. Weekly average long-lived gross beta air concentrations from EBR-I, Mud Lake, and the average of background air monitoring stations compared to monthly ICPP (nongaseous) release data

When the EBR-I and Mud Lake gross beta concentrations are graphically compared to the background average concentration (figure 3), the beta air concentration at Mud Lake and EBR-I appear to be relatively higher than background determinations during July, February, and June. These above background peaks appear to correlate with ICPP atmospheric release data which indicate that relatively larger releases of radioactivity occurred in July, February, and June than during the other months (figure 3). During July, more airborne radioactivity was released from ICPP than during February and June. However, the difference between background and the Mud Lake data was not as great as the difference observed in February and June. This condition may have been the result of the higher worldwide fallout in July (due to a recent atmospheric test) that masked the relatively low NRTS contribution.

Therefore, it appears that the average onsite gross beta air concentration at some locations during FY-1973 was higher than background levels as a result of NRTS atmospheric releases. However, the gross beta air concentrations at the boundary communities were not different from that which occurred in the background areas. Small amounts of activity resulting from NRTS activities were detected

at least at one boundary community (Mud Lake), but the NRTS contribution at this location was so minute that it did not significantly alter the average air concentration.

The iodine-131 concentrations were near or below the minimum detection limits for the analysis (table 2). The highest onsite observation was 76 fCi/m³ at TRA and the highest offsite determination, 54 fCi/m³, occurred at Montevieu. Both maximums were recorded in July during the passing of fallout from nuclear atmospheric testing. Both maximums were a small fraction of the guide value of 100 pCi/m³ (assuming that the exposure is due to inhalation only and not via the milk-food chain) for an individual in an uncontrolled area (1).

Further evidence for the low levels of activity in air can be seen in the data tabulated from the gamma spectra and strontium-90 analysis of the quarterly composites of the weekly air filters (table 3). Only during the first quarter of FY-1973 were any gamma-emitting nuclides detected in the filters above the minimum detection limits. During the first quarter, levels of activity in the air were relatively higher at all locations (figure 3) because of the increased worldwide fallout. The detected nuclides in the first quarter composite filters most likely are due to this relatively higher

Table 3. Results of gamma spectra analyses and strontium-90 analyses of quarterly composites of weekly air filters at the National Reactor Testing Station, FY 1973

Analysis	Offsite air concentrations (fCi/m ³)						Onsite air concentrations (fCi/m ³)	
	Idaho Falls		Butte City		Mud Lake		EBR-I	
	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
Antimony-125.....	(a)	(a)	11	(b)	(a)	(a)	5	(b)
Cesium-137.....	3	(b)	14	(b)	7	(b)	5	(b)
Zirconium-95.....	5	(b)	7	(b)	6	(b)	(a)	(a)
Niobium-95.....	83	(b)	13	(b)	6	(b)	(a)	(a)
Strontium-90.....	6	3	3	2	3	2	6	3
Cerium-141.....	2	(b)	(a)	(a)	(a)	(a)	5	(b)
Cerium-144.....	12	(b)	(a)	(a)	15	(b)	23	(b)
Ruthenium-103.....	4	(b)	(a)	(a)	3	(b)	5	(b)

^a Below detection limit. Detection limits varied because of different air flow volumes and counting times.

^b A meaningful average could not be computed; the radionuclide was detected in only one quarterly composite sample.

worldwide fallout. Strontium-90 determinations were similar at both onsite and background stations and also are believed to be the result of worldwide fallout. The highest strontium-90 concentrations occurred at EBR-I and Idaho Falls. These concentrations were a small fraction of the guide value of 30 pCi/m³ for an individual in an uncontrolled area.

Calculations show that the maximum 1972 whole body dose to an individual in an offsite population resulting from direct exposure or to inhalation of NRTS radioactive atmospheric effluents (both gaseous and particulates) was 1.5 mrem. The computed exposure to the population (66 918) residing within 80 km (50 miles) of the NRTS during 1972 was 2.4 manrem (3).

Monitoring of external radiation

In order to determine any addition from NRTS facilities to the natural background gamma and x-radiation exposure levels, thermoluminescent dosimeters (TLD) are employed at various onsite facilities as well as boundary and background or control communities (figure 4).

The TLD's consist of 3.18 mm × 3.18 mm × 0.89 mm thick Harshaw TLD-700 LiF chips. Each series of five chips was enclosed by 0.76 mm thick plastic and inserted into a steel dosimeter badge holder. The chips were posi-

tioned under an open window covered with waterproof tape. Generally, one badge with five chips was positioned approximately 1 meter above the ground surface at each onsite location. Five badges or a total of 25 LiF chips were utilized at each boundary community location and a total of 10 LiF chips was placed at the background locations. (The steel dosimetry badges no longer are used; instead beginning in May 1973, the LiF chips are attached to a paper card, covered by aluminized mylar punch tape and laminated with 0.25 mm thick plastic and inserted into a 5 × 10 cm card holder for field deployment.) The sampling stations are operated on a 6-month-exchange schedule. Generally, the TLD stations around NRTS facilities are located at regular intervals near the exclusion fences which surround these facilities. The TLD's on U.S. Highway 20, which crosses the site, are located at 2-mile intervals as are the TLD's on Lincoln Boulevard/Idaho Highway 88, the main NRTS north-south highway.

The chips are analyzed with a Model 2000 Harshaw Thermoluminescent Detector. The readings are compared to those from identical calibration LiF chips which received known exposures from a radium-226 source. The average boundary exposure (table 4), 146 ± 12 mR was not significantly different from the average background exposure of 156 ± 13 mR. This indicates that the exposures at the boundary

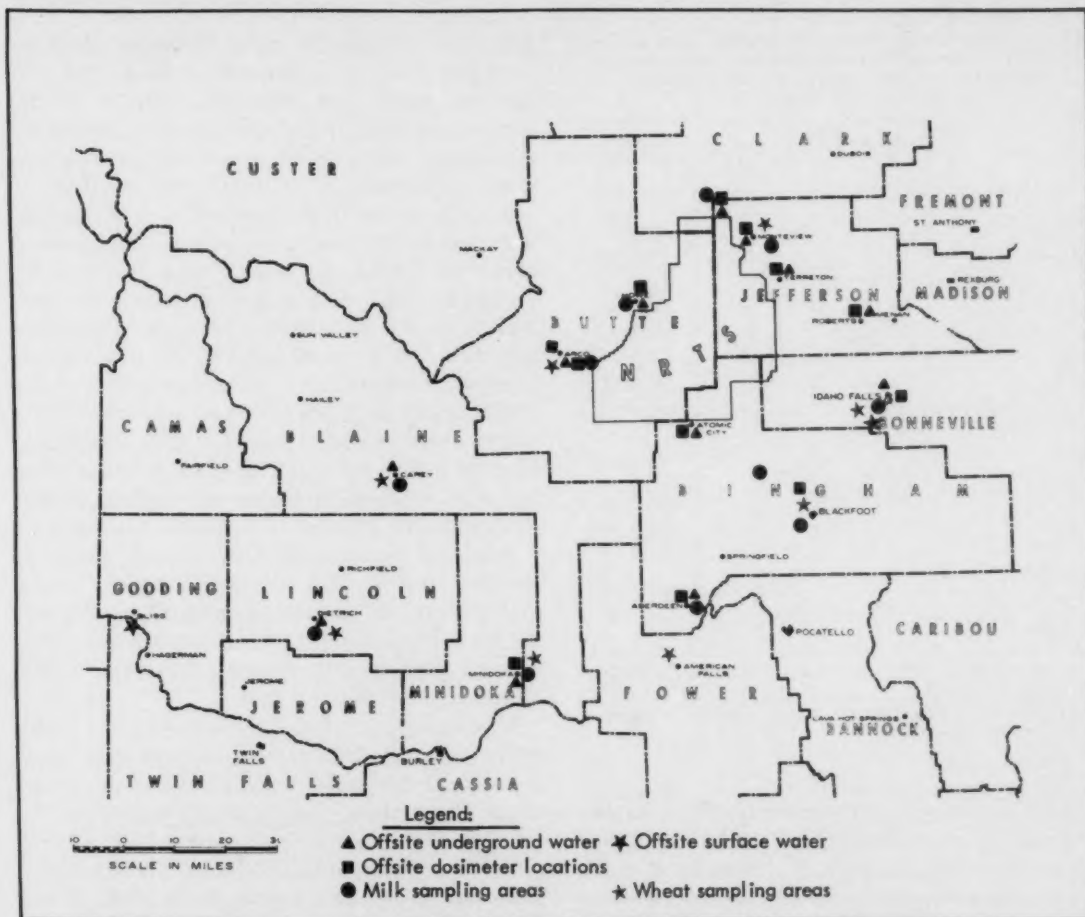


Figure 4. Offsite sampling stations, NRTS

locations are due to natural terrestrial and solar radiation and not due to NRTS activities. The variation among exposures from different locations indicates the variability of these natural sources.

Onsite average exposures were higher in the EBR-II, TRA, ARA I & II, RSA, ICPP, and CFA areas. These higher values were due to one or more of the following factors: operation of a facility, storage of radioactive waste, or the presence of radioactivity in evaporation ponds. In the ICPP and ARA areas, part of the exposures may be due to surface radioactive contamination around the facilities. The higher CFA average exposure resulted from a moni-

toring station near the Health Services Laboratory. This station documents exposures from a radioactive storage vault and a calibration source inside the laboratory near the TLD station.

Soil sampling

In order to establish levels in the soil and to assess any long-term buildup of activity, soil samples were collected from several onsite, boundary, and background locations during 1971 (figure 5). Generally onsite samples were collected from locations 0.5 to 1.6 km north-east and southwest of various NRTS facilities

Table 4. Summary of thermoluminescent dosimeter exposure data from the National Reactor Testing Station, boundary and background control locations, (May 1972 to May 1973)

Area	Sampling locations	Number of TLD's at each location	Exposure (mR/year)
Onsite:			
ARA-I & II	4	5	500 ± 400
SPERT	6	5	145 ± 7
CFA	3	5	200 ± 100
RSA	18	5	1400 ± 2000
U.S. Hwy 20	b10	5	140 ± 20
Lincoln Blvd/Hwy 88	13	5	150 ± 10
EBR-II	b8	5	200 ± 100
TREAT	2	5	135 ± 6
TSF	1	5	166 ± 6
LOFT	3	5	144 ± 7
LPTF	4	5	135 ± 5
NRF	11	5	160 ± 20
ICPP	13	5	500 ± 200
TRA	13	5	1600 ± 1900
EBR-I	1	25	160 ± 8
Boundary:			
Howe	1	25	135 ± 5
Montevue	1	25	139 ± 5
Reno Ranch	1	25	136 ± 5
Atomic City	1	25	170 ± 10
Arco	1	25	144 ± 4
Butte City	1	25	150 ± 6
Mud Lake	1	25	147 ± 6
Background:			
Minidoka	1	10	143 ± 5
Aberdeen	1	10	173 ± 9
Roberts	1	10	160 ± 10
Blackfoot	1	10	151 ± 6

* Standard deviation (SD) of the mean of the exposure at different locations near each facility.

^b This area had one less location during the first 6 months.

^c SD of boundary and background exposure is the SD of the mean of the TLD chips at that location.

at points of likely maximum deposition based on stack height, predominant wind direction and average stability class. Soil samples at each selected location were collected by taking five

soil cores or plugs, 10 cm in diameter and 5 cm in depth from a square meter area. The five samples were then combined into a single, composited, pulverized sample and plutonium, strontium, and gamma spectrometry analyses were performed on the < 0.5 mm fraction.

Results from boundary and onsite samples were compared to samples from the background areas of Blackfoot, Minidoka, and Pocatello (table 5). Only the gamma-emitting isotopes which were consistently above the minimum detection limits were included in this report. Generally, results from the background samples were similar to those collected near the NRTS boundary. Average cesium-137 and strontium-90 levels near the ICPP and ARA areas were a factor of 4 to 8 higher than background. Although the number of samples was limited, it appeared that strontium-90 levels at locations sampled onsite and on the boundary were higher than background samples. These slightly larger averages, if real, are probably the result of past atmospheric releases from the Idaho Chemical Processing Plant.

Plutonium-239 levels (average of 0.061 pCi/g) near the Radioactive Storage Area were slightly higher than concentrations in other areas. The highest plutonium-239 concentration (0.09 pCi/g) occurred in a boundary sample south southeast of EBR-II. A Radioecology Program study has begun to further define

Table 5. Results of onsite, boundary, and background soil monitoring at the National Reactor Testing Station January-December 1971

Location	Number of samples	Plutonium-239 (pCi/g dry weight)		Plutonium-238 (pCi/g dry weight)		Strontium-90 (pCi/g dry weight)		Cesium-137 (pCi/g dry weight)		Cesium-praseodymium-144 (pCi/g dry weight)	
		Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
ICPP	6 * 6	0.036	0.026 ± 0.01	0.059	0.025 ± 0.018	27.0	7.0 ± 10.0	24	8.0 ± 3.6	.9	b 0.5 ± 0.6
RSA	4 * 4	.077	.061 ± .018	.005	.005 ± .00	NA	NA	1.2	1.0 ± 2.4	.9	.6 ± .02
BORAX	1 2	.04	.04	NA	NA	NA	NA	1.5	.8	.7	.4 ± .5
TREAT, EBR-II	6 6	.024	.013 ± .006	.006	.004 ± .00	0.80	0.56 ± .21	2.0	.8 ± .6	.5	.4 ± .1
SPERT	2 6	.022	.015 ± .009	.005	.005 ± .00	NA	NA	1.0	.6 ± .02	.5	.2 ± .4
ARA	4 7	.024	.020 ± .006	.004	.002 ± .00	8.3	3.0 ± 3.5	21.0	4.7 ± 7.4	.7	.2 ± .4
TSF	1 2	.021	.021	< .001	< .001	NA	NA	.7	.6	.3	.2 ± .3
IET	1 2	.009	.009	< .005	< .005	.6	.6	.6	.4	.2	.1 ± .2
EBR-I	2 2	.035	.022 ± .018	.001	.001 ± .00	NA	NA	1.0	.8 ± .4	.5	.2 ± .4
NRF	0 2	NA	NA	NA	NA	NA	NA	.9	.7 ± .3	.5	.2 ± .4
TRA	0 2	NA	NA	NA	NA	NA	NA	.8	.8 ± .7	.0	.6 ± .6
Boundary ^c	10 10	.09	.031 ± .025	.006	.003 ± .002	1.31	.66 ± .35	1.6	.92 ± .47	.9	.5 ± .2
Background	4 4	.067	.031 ± .025	.009	.005 ± .004	.35	.09 ± .3	2.6	1.4 ± .09	.53	.32 ± .15

* Samples for gamma spectrometry.

^b Indicates range of average, ± indicates standard deviation.

^c See figure 5 for background and boundary sample locations.

NA, no analysis.

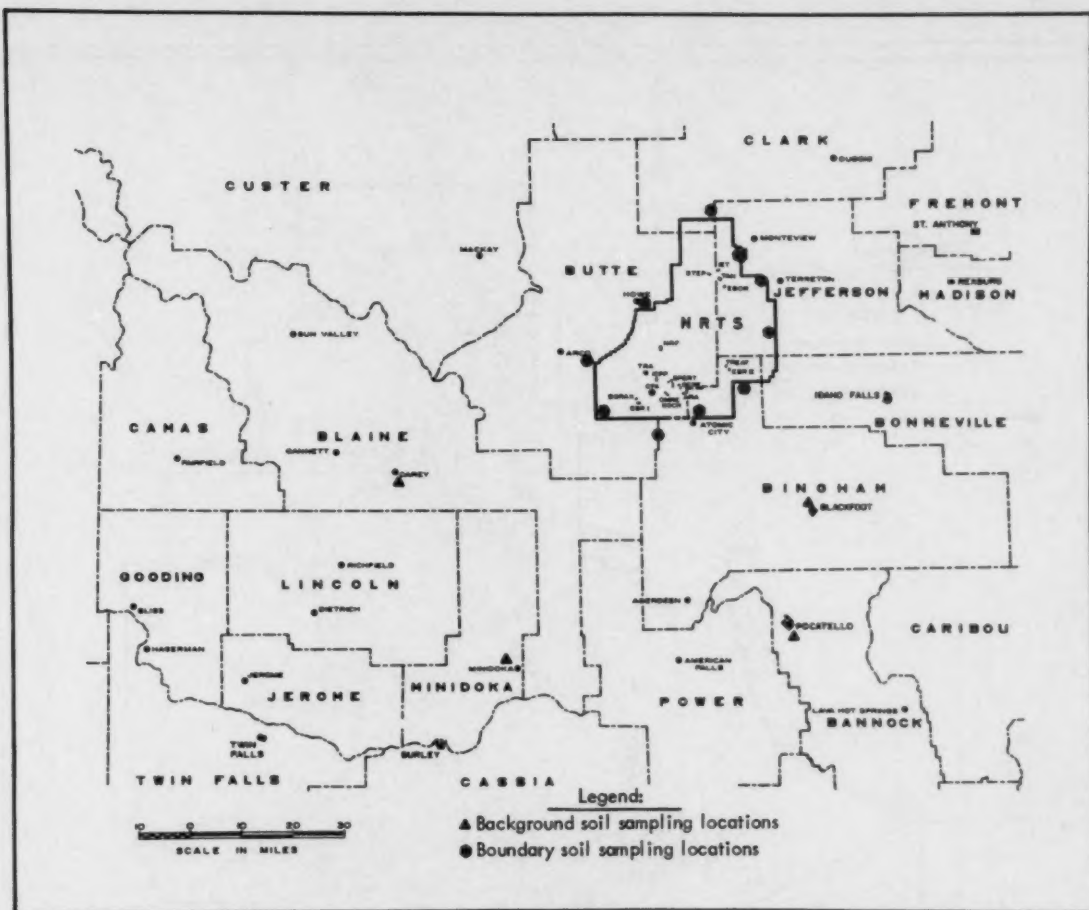


Figure 5. Locations of NRTS boundary and background soil samples

and document levels of transuranic, gamma-emitting nuclides and strontium-90 in the ecosystem near the Radioactive Storage Area. When the study is completed, data will be published in a separate paper.

The average plutonium-238 level of 0.025 pCi/g near the ICPP appeared to be slightly higher than samples from other locations. Plans have been formulated to collect additional samples in FY-1974 near and downwind of the Idaho Chemical Processing Plant. These additional samples will supply the necessary data to permit a realistic evaluation of soil contamination levels resulting from ICPP operations.

In the future, the soil monitoring program at the NRTS will provide for more detailed sampling in certain areas as well as periodic resampling of larger areas in order to monitor any possible increased activity in the soil.

Water monitoring program

Although the NRTS receives an average of approximately 20 cm (8 inches) of precipitation per year, underlying the desert plain is the large Snake River Plain aquifer. The lateral flow of this water, the major aquifer of Idaho, is about 3.75×10^9 liters (10^9 gallons) per day. The aquifer recharge to the NRTS area origi-

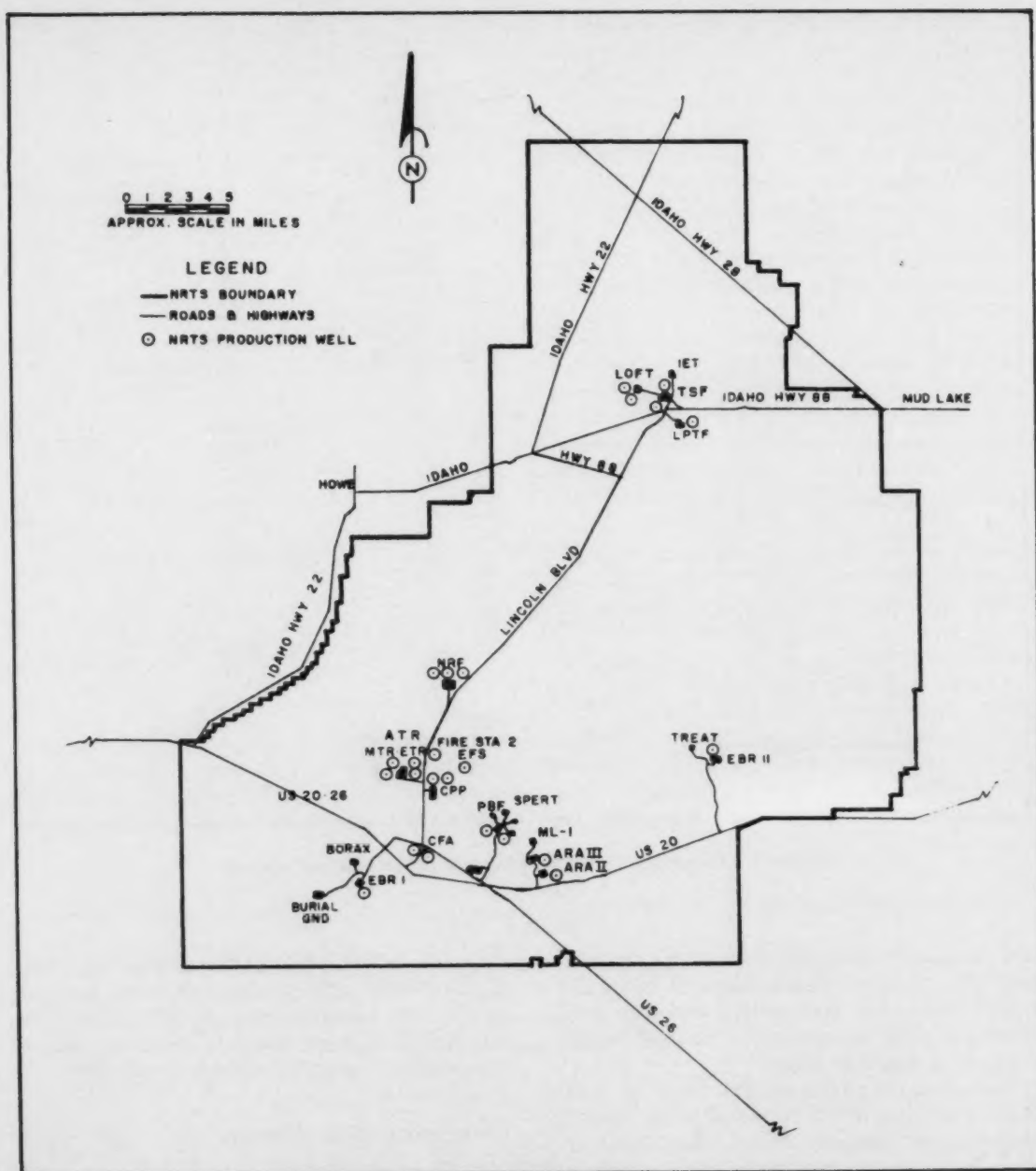


Figure 6. Location of NRTS drinking water production wells

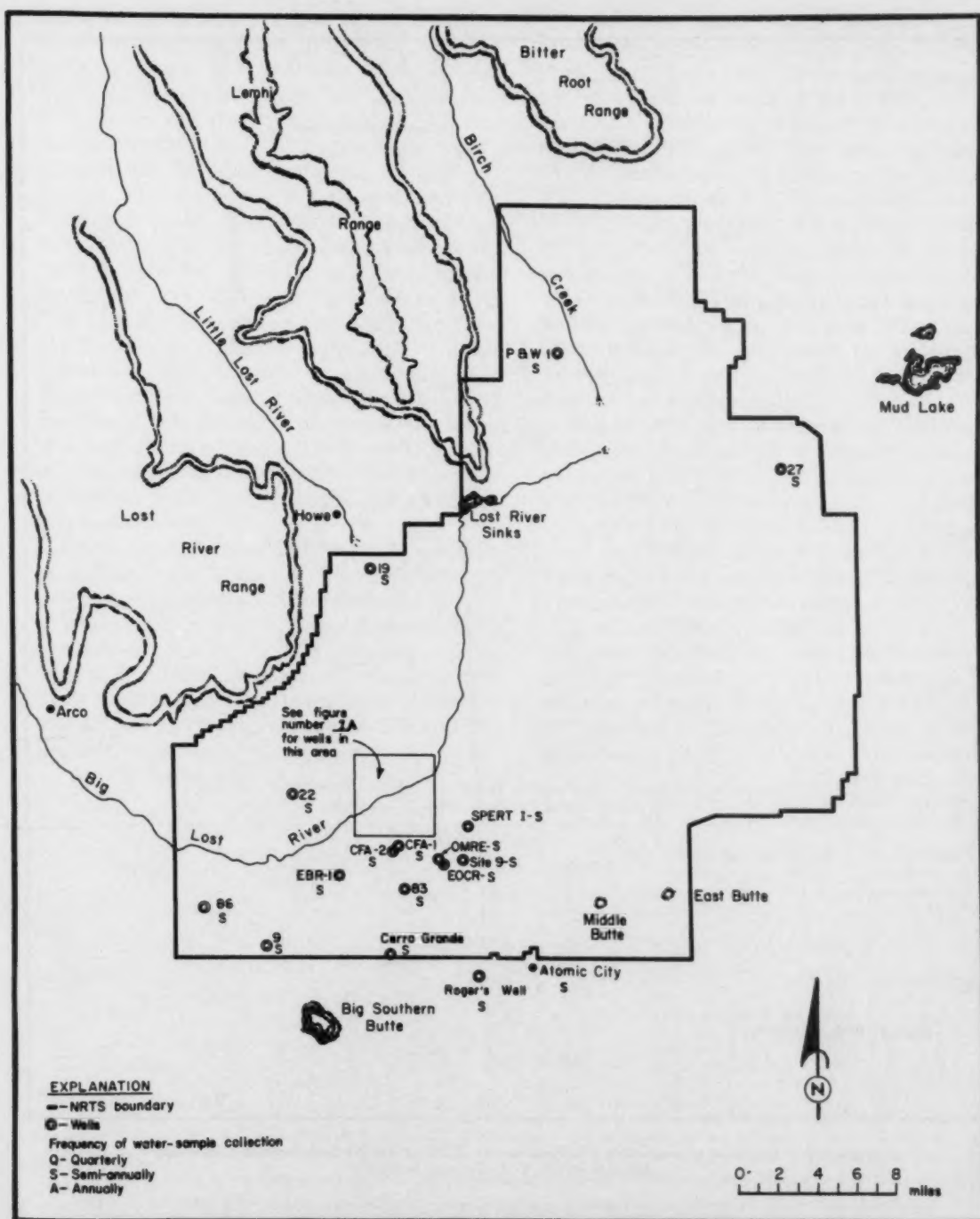


Figure 7. Location of monitoring wells on the NRTS and frequency of sample collection by the U.S. Geological Survey

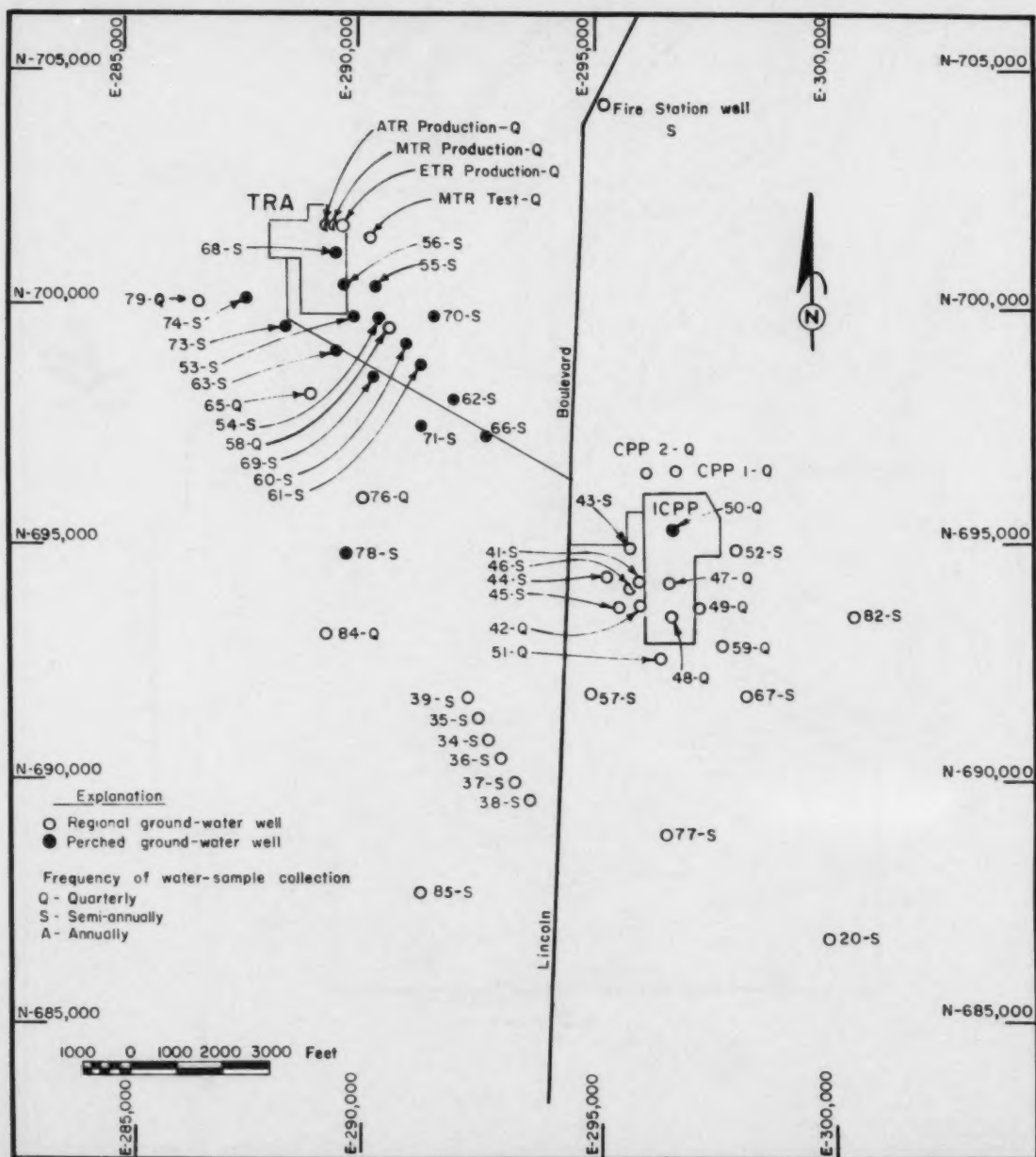


Figure 8. Location of monitoring wells near the ICRP and TRA and frequency of sample collection by the U.S. Geological Survey

nates primarily as underflow from the north-eastern part of the Snake River Plain and also north, northeast, and northwest of the station. Additional water comes from the Big and Little Lost Rivers and Birch Creek which sink into the porous soils in the NRTS area. These waters move slowly south or southwest through the aquifer and discharge at numerous springs along the Snake River between Milner and Bliss, Idaho. Aquifer water of the Snake River Plain is used for irrigation of crops and domestic purposes. NRTS facilities obtain water from this aquifer and some discharge low level liquid radioactive waste into the aquifer. Other radioactive waste water is discharged into shallow ponds and slowly percolates downward. Because of this discharge of wastes, the water sampling program monitors radioactivity levels through periodic sampling of drinking water production wells, special monitoring wells and the Snake River.

Water samples from NRTS drinking water production wells (figure 6) normally are collected every 3 weeks, while offsite production wells and surface waters (figure 4) are sampled semiannually by the HSL. Gross alpha, gross beta, and tritium activities are measured routinely on all samples and, in addition, strontium-90 analyses are performed on the ICPP drinking water samples.

In addition to the Health Services Laboratory's sampling of production wells, the U.S. Geological Survey periodically samples a number of monitoring wells of the NRTS (figures 7 and 8). The majority of these wells are located near the ICPP, where low level radioactive waste water is returned to the aquifer, and near TRA, where waste disposal ponds are utilized. Some of these wells monitor the regional aquifer while others monitor water which has percolated downward but remains perched above the regional aquifer. One well monitors a zone of perched water near the ICPP. Tritium concentrations are determined for all samples. Strontium-90 concentrations are measured for samples from selected wells.

The drilling of four additional monitoring wells near the Radioactive Storage Area was completed in FY-1973 and sampling initiated. Samples from these wells are being collected on a monthly basis during FY-1974.

All the samples (table 6) from the drinking water wells were below the minimum detectable concentration for gross alpha activity, and some of the samples from the ICPP were the only ones indicating gross beta levels above the minimum detection level. The maximum gross beta concentration detected in the ICPP area samples was 20 pCi/liter. This value is below the guide value of 30 pCi/liter for unidentified

Table 6. Results of drinking water and surface water sampling in the vicinity of the National Reactor Testing Station during FY 1973

Location	Number of wells	Samples collected	Gross alpha ^a (pCi/liter)		Gross beta ^b (pCi/liter)		Tritium ^c (nCi/liter)		Strontium-90 ^d (pCi/liter)	
			Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
Onsite:										
EBR-I	1	1	BDL	BDL	BDL	BDL	BDL	BDL		
CFA	2	26	BDL	BDL	BDL	BDL	90	59		
TRA	3	104	BDL	BDL	BDL	BDL	BDL	BDL		
ICPP	2	23	BDL	BDL	20	*1.4-5.9	6.0	*2.8-3.1	7.0	3.0
NRF	3	36	BDL	BDL	BDL	BDL	BDL	BDL		
TAN	5	126	BDL	BDL	BDL	BDL	BDL	BDL		
SPERT-PBF	2	26	BDL	BDL	BDL	BDL	BDL	BDL		
ARA	2	52	BDL	BDL	BDL	BDL	BDL	BDL		
EFS	1	1	BDL	BDL	BDL	BDL	BDL	BDL		
EBR-II	1	26	BDL	BDL	BDL	BDL	BDL	BDL		
Fire Station #2	1	26	BDL	BDL	BDL	BDL	BDL	BDL		
Offsite:										
12 locations (see figure 4)	12	24	BDL	BDL	BDL	BDL	BDL	BDL		
Snake River *	2	4	BDL	BDL	BDL	BDL	BDL	BDL		

^a AEC guide for gross alpha in drinking water is 30 pCi/liter for an individual in an uncontrolled area. Detection limit for gross alpha concentration is 3 pCi/liter.

^b AEC guide for gross beta in drinking water is 30 pCi/liter for an individual in an uncontrolled area. Detection limit for gross beta concentration is 5 pCi/liter.

^c AEC guide for tritium in drinking water is 3 pCi/liter for an individual in an uncontrolled area. Detection limit for tritium is 2 nCi/liter.

^d AEC guide for strontium-90 in drinking water is 300 pCi/liter for an individual in an uncontrolled area.

* The upper limit is calculated considering BDL at the detection level; for lower figure, BDL is considered as 0.

^e 80 samples from ICPP were analyzed for strontium-90.

^f Surface water samples.

BDL, below detectable levels.

beta emitters in drinking water (1). Levels of tritium above the detection limit were found in the ICPP and CFA area drinking water wells. The maximum tritium concentration in any single sample, 90 nCi/liter, is well below the guide value of 3 μ Ci/liter (1). The tritium detected in CFA water is a result of tritium released to the aquifer in the ICPP and TRA areas. The highest strontium-90 concentration in any one production well sample from the ICPP area was 7.0 pCi/liter. The strontium-90 concentration is less than 2.4 percent of the AEC guide value for strontium-90 in drinking water.

Results of the USGS samples from the regional and perched groundwater monitoring wells (table 7) in both the TRA and ICPP areas indicate that all tritium analyses were below the guide values for drinking water consumed by an individual in an uncontrolled area. The highest tritium concentration in a single sample from the regional aquifer was 199 nCi/liter or less than 7 percent of the drinking water value of 3 μ Ci/liter for an individual in an uncontrolled area. Two wells in the CFA area were the only other wells either on- or offsite where tritium concentrations were detected. As pointed out above, the tritium concentrations at CFA result from releases to the aquifer at the ICPP and TRA areas.

The highest sample analysis for strontium-90 from USGS wells monitoring the regional aquifer at ICPP was 220 pCi/liter which is about $\frac{3}{4}$ of the guide value of 300 pCi/liter for drinking water for an individual in an un-

controlled area. The average strontium-90 concentration in the regional aquifer, 40 pCi/liter, at ICPP was less than 15 percent of the guide value. Further evidence of the low levels of radioactive waste entering the regional aquifer is demonstrated by the perched groundwater data. The average strontium-90 concentrations in the perched aquifer both at TRA and ICPP were less than three times the drinking water guide values for an individual in an uncontrolled area. Even the maximum concentration recorded for a single sample from the perched aquifer was only four times the above guide values. These higher concentrations were observed in shallow wells monitoring perched water close to the liquid waste pond near TRA and near the disposal well at ICPP; these waters are neither accessible for use as drinking water nor in an area which is open to the public.

Food monitoring

The food monitoring program supplies information on amounts of radioactivity in food collected in the NRTS vicinity. Comparisons between levels of activity in food products collected near the NRTS boundary and similar samples collected in background areas provide a method for evaluating any increases of radioactivity in food as a result of NRTS operations.

Each week a composite Grade A milk sample is collected from areas north and south of Idaho Falls. Monthly samples of Grade B milk are collected from dairies and an individual farm

Table 7. Results of monitoring well sampling by the U.S. Geological Survey at the National Reactor Testing Station during FY 1973

Location	Number of wells	Ground-water type	Number of samples		Tritium ^a (nCi/liter)		Strontium-90 ^b (pCi/liter)	
			³ H	⁹⁰ Sr	Maximum	Average	Maximum	Average
TRA.....	8	Regional	38	—	173	*19-20	NA	NA
TRA.....	15	Perched	42	18	614	197	1 170	160
ICPP.....	28	Regional	69	47	199	50	220	40
ICPP.....	1	Perched	4	4	220	208	820	780
Other onsite.....	15	Regional	42	—	84	*11-13	NA	NA
Offsite.....	2	Regional	3	—	2	*0-2	NA	NA

^a AEC guide value (1) for drinking water is 3 μ Ci/liter for an individual in an uncontrolled area. These samples are from special monitoring wells which are not utilized for drinking water. Detection limit is 2 nCi/liter.

^b AEC guide value (1) for drinking water is 300 pCi/liter for an individual in an uncontrolled area.

^c The upper limit is calculated considering BDL at the detection level; for lower figure, BDL is considered as 0.

NA, no analysis.

in rural areas near the NRTS (figure 4). All milk samples are analyzed for cesium-137 and iodine-131 by gamma spectrometry and, semi-annually, the samples are analyzed for strontium-90.

During FY-1973, all milk samples were below the minimum detection limit (MDL) for cesium-137 and iodine-131. The MDL for cesium-137 in milk is 30 pCi/liter and for iodine-131 in milk, the MDL is 20 pCi/liter. Strontium-90 concentrations (table 8) were less than 1 percent of the guide (4) and are believed to be the result of worldwide fallout.

Table 8. Strontium-90 concentrations in milk samples collected near the National Reactor Testing Station, FY 1973

Location	Strontium-90 (pCi/liter)	
	Maximum	Average
Background:		
Idaho Falls *	3.0	3.0
Minidoka	3.0	3.0
Dietrich	3.0	*1.5-2.5
Carey	4.0	2.0-3.0
Firth & New Sweden (near Idaho Falls)	3.0	1.5-2.5
Lake & Riverside (Tabor, Blackfoot, Aberdeen areas)	4.0	2.0-3.0
Boundary:		
Mud Lake	6.0	5.2
Reno Ranch	3.0	1.5-2.5
Howe	BDL	BDL
Arco	BDL	BDL

* Only two samples from each location were analyzed during the year for strontium-90.

^b BDL=below detection limits. The MDL for strontium-90 in milk is 2 pCi/liter.

^c The upper limit is calculated considering BDL at detection level, lower figure is considering BDL as 0.

During the fall, wheat samples consisting of both seed and hulls from farms and elevators near the NRTS boundary and at greater distances (figure 4) are analyzed for strontium-90. In addition, the wheat sample from Montevieu, a boundary community, was analyzed by gamma spectrometry. No gamma-emitting isotopes other than those which occur naturally were detected. Strontium-90 activity levels (table 9) in wheat close to the site boundaries were similar to determinations in samples at greater distances. These levels are believed to be the result of worldwide fallout and not due to NRTS activities.

Antelope (*Antilocapra americana*) are present on and near the NRTS during most of the year. Since the area around the NRTS is open

Table 9. Strontium-90 in wheat samples near the NRTS during fall 1972

Sampling location	Strontium-90 concentration (pCi/kg)
Arco	*11 ± 2
Montevieu	25 ± 2
Minidoka	21 ± 2
Dietrich	22 ± 2
Carey	16 ± 7
Idaho Falls	22 ± 2
Blackfoot	10 ± 2
American Falls	13 ± 2

* Standard deviation from counting statistics.

to hunting and antelope are consumed by sportsmen, these animals represent a potential source of radionuclide intake by man. Various antelope tissues are sensitive bioindicators of levels of certain radionuclides in the environment and thereby provide knowledge concerning the ultimate fate of radionuclides released to the atmosphere. Therefore, a study was designed as part of the radioecology program whereby antelope routinely are collected on a monthly basis on and near the NRTS. Additional samples from road accidents and sportsmen-donated samples also are utilized.

The thyroid, muscle, lungs, liver, and rumen samples collected are analyzed by gamma spectrometry. Additional analysis for strontium-90 levels in bone and analyses of bone and lung samples for transuranic nuclides are planned. In this report, the levels in edible (liver and muscle) parts of the animals are presented (table 10).

With one exception, cesium-137, cesium-134, and cobalt-60 were the only isotopes detected in liver and muscle tissues. Cobalt-60 was present in only a few samples and when present was slightly above the minimum detection limit. Cesium-134 was detectable only in onsite samples collected near the ICPP. Cesium-137 levels in muscle and liver samples from animals collected onsite were significantly higher ($\alpha = 0.05$) than those collected offsite. The highest cesium-137 levels detected were 1130 pCi/kg muscle and 1770 pCi/kg liver. These samples, as well as others collected near the ICPP, were higher than samples from other locations. Off-site samples had cesium-137 levels of 22-60 pCi/kg of muscle and 31-80 pCi/kg of liver.

Table 10. Gamma emitting isotopes present in muscle and liver samples from antelope on and near the National Teactor Testing Station

Antelope collection number	Date	Distance and direction from ICPP (km)	Muscle			Liver		
			¹³⁷ Cs ^a (pCi/kg wet weight)	¹³⁴ Cs ^a (pCi/kg wet weight)	⁶⁰ Co ^a (pCi/kg wet weight)	¹³⁷ Cs ^a (pCi/kg wet weight)	¹³⁴ Cs ^a (pCi/kg wet weight)	⁶⁰ Co ^a (pCi/kg wet weight)
Offsite:								
72-1	9-23-72	84 NNW	38	* BDL	16	50	BDL	BDL
72-2	9-24-72	93 NNW	54	BDL	19	46	BDL	BDL
72-3	9-24-72	88 NNE	46	BDL	BDL	NA	NA	NA
72-4	9-24-72	74 NE	40	BDL	40	80	BDL	BDL
72-5	9-24-72	88 NE	60	BDL	60	50	BDL	BDL
73-1	1-12-73	90 NE	22	BDL	BDL	NA	NA	NA
73-2	2- 9-73	37 NW	53	BDL	BDL	73	BDL	BDL
73-5	5-11-73	85 NW	BDL	BDL	BDL	31	BDL	BDL
Onsite:								
72-7	10- 8-72	31 NNE	130	BDL	32	100	BDL	60
72-8	10-16-72	.4 N	920	BDL	BDL	1430	71	BDL
72-9	11- 6-72	.4 S	1130	100	BDL	1770	120	BDL
72-10	11- 9-72	6 SW	680	BDL	BDL	1740	150	BDL
72-11	11- 9-72	6 SW	680	BDL	BDL	1670	120	BDL
72-12	12-19-72	47 NNE	29	BDL	BDL	46	BDL	BDL
73-3	3- 9-73	6 SE	29	BDL	BDL	60	BDL	BDL
73-4	4-20-73	2 E	240	11	BDL	870	60	BDL
73-6	6-22-73	3 SW	430	BDL	BDL	64	BDL	BDL

* Detection limits were: 10 pCi/kg for cesium-134 and 10 to 40 pCi/kg for cobalt-60. Detection limit for cesium-137 was 20 pCi/kg except for 73-5 muscle which was 200 pCi/kg.

^b The liver sample from this animal contained 10 pCi/kg of manganese-54.

BDL, below detectable level.

NA, no analysis.

From the data collected during FY-1973, it appears that the cesium levels in the tissues of the animals collected offsite were the result of worldwide fallout with possible small contributions from NRTS activities. More samples at various locations near the boundary and offsite are needed. Also, samples have not been collected during a major waste solidification operation at ICPP. Therefore, a detailed analysis of the data with respect to distance and direction from ICPP cannot be attempted. Additional samples will be collected during the next 2 years. When sufficient data are available, the results will be reported in a future publication. However, the antelope on the NRTS probably do not contribute significantly to the radionuclide intake of sportsmen since the NRTS is closed to hunting. If the animals leave the NRTS, the cesium levels in their bodies would rapidly come into equilibrium with their new environment, since the biological half-time of cesium in antelope probably is similar to the 14-day period observed in other wild ruminant species (5). Further, the fall antelope migration across the NRTS does not occur until after the hunting season. If a sportsman consumed an entire antelope with the highest level of cesium-137 in muscle and with the highest level

of cesium-137 in the liver of the animals collected to date, calculations (6) indicate that he would receive a radiation dose of < 2 mrem.

Iodine-129 monitoring

During processing of spent nuclear fuels and calcination of resultant liquid wastes at the Idaho Chemical Processing Plant, small amounts of iodine-129 are present in the atmospheric effluent. The Radioecology Program is attempting to determine the accumulative deposition of iodine-129 in the NRTS and surrounding environs and to establish a monitoring program for current iodine-129 releases.

Beginning in September 1972, thyroids obtained from a monthly antelope collection as well as samples obtained from road-killed antelope have been analyzed for iodine-129 and stable iodine. Iodine-129 levels are determined by activation analysis techniques and iodine-127 levels are determined spectrophotometrically. Thyroids collected after April 1973 will be analyzed at a later date since the ETR, previously used to irradiate samples, is no longer operating on a continuous basis and a new irradiation facility is not yet complete.

Specific activity of iodine-129, the ratio of

the activity of iodine-129 to the mass of stable iodine (^{127}I), varied from 69 nCi $^{129}\text{I/g}$ iodine in a thyroid sample collected 6 km southwest of ICPP to 0.28 nCi $^{129}\text{I/g}$ iodine in a thyroid sample collected 90 km northeast of ICPP (table 11). All the thyroids collected were above the average background level of 17 ± 14 pCi $^{129}\text{I/g}$ iodine as determined for eight mule deer thyroids from New Mexico and Colorado.² The specific activities in the background samples were similar to levels in bovine thyroids in Massachusetts (7). The highest specific activity determined was only 5 percent of the limiting specific activity of 1.4 $\mu\text{Ci } ^{129}\text{I/g}$ iodine (8). The limiting specific activity is that specific activity which, if present in a human thyroid, would result in a dose rate of 500 mrem/yr, the dose limit for an individual in an exposed population. However, the data on antelope thyroids is not directly applicable to humans in the NRTS area since the fraction of total iodine intake from local sources for the surrounding population is not known.

Table 11. Specific activity of iodine-129 in antelope thyroids on and near the National Reactor Testing Station

Antelope number	Date of collection	Distance and direction from ICPP (km)	nCi $^{129}\text{I/g}$ iodine
72-7	10- 8-72	31 NNE	*2.2
72-8	10-16-72	0.4 N	*47
72-10	11- 9-72	6 SW	*49
72-11	11- 9-72	6 SW	*69
72-12	12-19-72	47 NNE	7.9
73-1	1-12-73	90 NE	2.8
73-2	2- 9-73	37 NW	2.4
73-3	3- 9-73	7 SE	2.1
73-4	4-20-73	2 E	9.6

* Iodine-127 levels not determined in this sample. An average iodine-127 value of 1120 $\mu\text{g/g}$ tissue determined from other antelope thyroid samples was used in this calculation.

The biological half-life of iodine in antelope thyroids probably is similar to the 33-day half-life of iodine in mule deer thyroids (9). Since the antelope collected near the ICPP during October and November were thought to be part of a migrating herd which had been in the area only a short time, it is doubtful that the thyroid iodine-129 levels were in equilibrium with the environment in that area. The antelope (72-12,

73-1, 73-2) collected at more distant locations most likely were as close to ICPP at the time of collection as they had been at any other time in the previous 6 months. Therefore, the iodine-129 levels in these thyroids may be representative of those found in the environment in the area where they were collected and were not due to recent travels nearer the ICPP.

Many more samples from different directions and locations need to be collected before the distribution of iodine-129 in the NRTS and surrounding area can be completely described. However, preliminary data do indicate that effluents from the ICPP during the previous 19 years have increased the iodine-129 levels in the terrestrial ecosystem at the NRTS and surrounding area. The data further demonstrate that the levels still are only a fraction of the limiting specific activity.

Beginning in the fall 1973, antelope thyroids will be collected from cooperating sportsmen in antelope hunting areas surrounding the NRTS and extending into mountain valleys to the north and northeast. In addition, a number of deer thyroids will be obtained from the mountains near the upper Snake River Plain. Analysis of these thyroids should provide the necessary data to determine the amount and extent of iodine-129 deposition in the upper Snake River Plain as well as the mountainous area adjacent to the Plain. More thyroids will be sought from other parts of Idaho and other Rocky Mountain areas remote from the NRTS to improve our estimate of the concentration from weapons testing fallout.

Summary

This report describes the results of the environmental monitoring program conducted by the Health Services Laboratory at the National Reactor Testing Station. The results of the NRTS air monitoring program for FY-1973 indicated that some onsite monitoring stations had increased gross beta air concentrations as a result of NRTS operations. Although NRTS atmospheric releases occasionally were detected at one boundary monitoring station, the NRTS contribution at this location was so minute that it did not significantly alter the gross beta average air concentration.

² Unpublished data, O. D. Markham, C. P. Willis, T. E. Hakonson, and F. W. Whicker.

Calculations show that the maximum 1972 whole body dose to an individual in an offsite population resulting from direct exposure to or inhalation of NRTS radioactive atmospheric effluents (both gaseous and particulates) was 1.5 mrem. The computed exposure to the population (66 918) residing within 80 km (50 miles) of the NRTS during 1972 was 2.4 man-rem.

None of the offsite well water or surface water samples contained any gross alpha, gross beta, or tritium activity above the detection limits for these analyses. The only radioactivity detected in water was from samples collected at onsite locations in the ICPP, TRA, and CFA areas; the observed levels in the aquifer were below the appropriate guide values for drinking water.

Thermoluminescent dosimeters deployed at various onsite, boundary and background locations indicated that NRTS activities did not increase the offsite radiation exposure. At several onsite monitoring locations, the exposures were higher than control monitoring locations as the result of operations of facilities, storage of radioactive waste or radioactivity in evaporation ponds and possibly surface radioactive contamination.

Radioactivity concentrations in soil samples collected near the boundary of the NRTS generally were similar to those collected in background locations; however, it appeared from a limited number of samples that average strontium-90 levels at locations onsite and on the boundary were higher than background averages.

The only fission or activation product detected in milk and wheat was strontium-90, and the levels are believed to result from worldwide fallout from previous nuclear weapons testing and not related to NRTS operations.

Cesium-137, cesium-134, and cobalt-60 were detected in edible portions of antelope. Cesium-134 was detected only in onsite samples collected near the ICPP. Cobalt-60 was present in a few samples and when present was only slightly above the detection limits. Cesium-137 in muscle and liver samples collected from onsite antelope were significantly higher than samples from offsite animals. The highest level

of cesium-137 detected in muscle was 1130 pCi/kg and the highest level in liver was 1770 pCi/kg. The potential dose to an individual consuming a whole antelope with the highest tissue concentrations is less than 2 mrem.

Sampling for iodine-129 on and near the NRTS indicates that releases from the ICPP have increased the iodine-129 level in the terrestrial ecosystem at the NRTS and surrounding area. However, the samples analyzed to date indicate that the specific activities of iodine-129 found in the NRTS environment are only a fraction of that which, if present in humans, would give the maximum permissible level for iodine-129.

Acknowledgements

Appreciation is extended to the Idaho Fish and Game Department for permission and assistance in collecting antelope samples. P. G. Voillequé, A. H. Dahl and W. L. Polzer critically reviewed the manuscript and offered many useful comments.

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Personnel and Environmental Thermoluminescent Dosimetry for a University Reactor Located in a Semitropical Area

P. S. Weng¹ and C. Y. Huan²

The ⁶LiF-Teflon discs were added to the film badges for personnel monitoring during a 6-month period. The results showed a consistently higher dose in the thermoluminescent dosimeter than in the photographic film dosimeter, which might exhibit about 90 percent fading during the 4-week period in a hot and humid climate. In winter time, it was found that the response from both LiF-Teflon disc and film showed more consistent results due to better climate conditions in Taiwan. The CaSO₄:Dy and CaSO₄:Tm phosphor powders and LiF:Mg, Ti, enclosed in a knot of bamboo stick, were used for environmental monitoring at a university reactor site and inside a research reactor building. The results showed that they were unaffected by extremes of humidity and environmental temperatures in area monitoring, either indoors or outdoors.

Since Taiwan is an island located near the tropical zone, it is important to select dosimeters for both personnel and environmental monitoring that are usable under conditions of high temperature and humidity. A photographic film dosimeter had been used for this purpose since 1961. A recent test showed that gamma-irradiated Kodak Personnel Monitoring Film Type 2 stored in the ambient climate exhibited about 60 to 90 percent fading during 4 weeks with little protection provided by additional sealing (1). The test was carried out during May and June which are not the hottest and most humid months in Taiwan (temperature varied between 23 and 33°C, relative humidity between 75 and 95 percent).

A personnel radiation exposure obviously can occur at the beginning as well as at the end of the monitoring period. The high fading rate makes the application of any correction factors quite difficult. The same situation occurred for the environmental monitoring. The change from the film badge to the more accurate and stable solid-state dosimeters was necessary.

Personnel dosimetry

The most conservative approach was adopted, i.e., to add TLD detectors to the film badge for several months. The 13 mm diameter \times 0.4 mm thick discs of LiF-Teflon of Tele-dyne Isotopes were used because of the consideration of obtaining maximum sensitivity. The minimum dose, defined as three times the standard deviation of the background, was 15 mrad. The tissue-equivalence of LiF-Teflon dosimeters enables meaningful estimates of dose in x or gamma radiation from a single measurement of a dosimeter for the personnel monitored. The response is independent of photon energy to within 30 percent down to 20 keV. In addition, the LiF-Teflon discs are unaffected by extremes of humidity and environmental temperatures which exist in Taiwan. Readout of LiF-Teflon discs was performed on Tele-dyne Isotopes model 7100 TLD instrument. Nitrogen was supplied to suppress the spurious thermoluminescence during the readout procedure. The standard deviation of the results was about 3.6 percent.

The LiF-Teflon disc was inserted between the Kodak Personnel Monitoring Film Type 2 (for beta, x, and gamma rays, and Type A (for neutrons) which in turn were inserted into the badge. The description of the Tsing Hua Film

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Badge has been reported elsewhere (2). The calibration of the TLD reader was carried out by comparing it with a Victoreen R-meter which measures the drop in potential of a charged capacitor due to an ionization current caused by radiation. A 100 mCi cesium-137 source was used for this calibration. Half a year's tests with personnel of the Radioisotope Section of National Tsing Hua University showed, as expected, a consistently higher dose in the LiF-Teflon disc than in the film. The results are presented in tables 1-6. The primary radiation source was iodine-131.

Table 1. Comparison between LiF-Teflon discs and film badges during 9 July to 6 August 1971

Number	Net doses from:	
	LiF-Teflon TLD	Film badge
1	BG	BG
2	25 mR	BG
3	27 mR	BG
4	BG	27 mR
5	12 mR	BG
6	10 mR	BG
7	BG	BG
8	BG	BG
9	BG	BG
10	BG	BG
11	13 mR	BG
12	11 mR	BG
13	BG	BG
14	BG	BG
15	10 mR	BG
16	14 mR	BG
17	13 mR	BG
18	15 mR	BG
19	17 mR	BG
20	16 mR	BG
21	BG	BG
22	25 mR	BG
23	19 mR	BG

Average background (BG) = 10 mR/4 weeks

Table 2. Comparison between LiF-Teflon discs and film badges during 6 August to 3 September 1971

Number	Net doses from:	
	LiF-Teflon TLD	Film badge
1	BG	BG
2	111 mR	BG
3	95 mR	85 mR
4	BG	BG
5	31 mR	27 mR
6	75 mR	71 mR
7	BG	BG
8	BG	BG
9	BG	BG
10	BG	BG
11	1960 mR	BG
12	BG	BG
13	BG	BG
14	BG	BG
15	BG	BG
16	BG	BG
17	BG	BG
18	BG	BG
19	BG	18 mR
20	BG	18 mR
21	1 mR	27 mR
22	BG	BG
23	BG	BG

Average background (BG) = 19 mR/4 weeks

Table 3. Comparison between LiF-Teflon discs and film badges during 3 September to 1 October 1971

Number	Net doses from:	
	LiF-Teflon TLD	Film badge
1	BG	BG
2	BG	BG
3	76 mR	BG
4	BG	BG
5	6 mR	BG
6	225 mR	48 mR
7	—	—
8	BG	BG
9	21 mR	BG
10	—	—
11	—	—
12	8 mR	BG
13	BG	BG
14	—	—
15	6 mR	BG
16	—	—
17	BG	54 mR
18	—	—
19	BG	BG
20	BG	BG
21	—	—
22	—	—
23	—	—

Average background (BG) = 23 mR/4 weeks

Table 4. Comparison between LiF-Teflon discs and film badges during 1 October to 29 October 1971

Number	Net doses from:	
	LiF-Teflon TLD	Film badge
1	BG	BG
2	BG	BG
3	22 mR	BG
4	BG	BG
5	BG	BG
6	145 mR	60 mR
7	66 mR	41 mR
8	BG	BG
9	BG	BG
10	BG	BG
11	BG	BG
12	BG	BG
13	55 mR	54 mR
14	BG	BG
15	BG	BG
16	—	—
17	BG	BG
18	BG	BG
19	4 mR	BG
20	10 mR	BG
21	BG	BG
22	—	—
23	—	—

Average background (BG) = 17 mR/4 weeks

The background reading also is presented for each disc and the average background reading for each monitoring period appears at the bottom of tables 1-6. The reading in milliroentgens for each monitoring disc is the net reading, i.e., the reading with the background subtracted.

Environmental monitoring

Two different types of dosimeters were selected. $\text{CaSO}_4:\text{Dy}$ and $\text{CaSO}_4:\text{Tm}$. The calcium sulfate phosphors were produced at National Tsing Hua University by the following procedure (3).

Table 5. Comparison between LiF-Teflon discs and film badges during 29 October to 26 November 1971

Number	Net doses from:	
	⁶ LiF-Teflon TLD	Film badge
1	BG	BG
2	12 mR	BG
3	48 mR	41 mR
4	BG	BG
5	BG	BG
6	65 mR	138 mR
7	11 mR	BG
8	—	—
9	190 mR	129 mR
10	—	—
11	11 mR	BG
12	16 mR	BG
13	—	—
14	14 mR	BG
15	BG	BG
16	—	—
17	BG	BG
18	BG	BG
19	BG	BG
20	25 mR	41 mR
21	BG	BG
22	11 mR	BG
23	191 mR	BG

Average background (BG) = 21 mR/4 weeks

Pure $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ was mixed with reagent grade activator material, Dy_2O_3 or Tm_2O_3 , to the extent of 0.1 mole percent with regard to CaSO_4 , and dissolved in concentrated sulfuric acid to form a saturated solution of CaSO_4 . The solution was then gradually heated up on a hot plate. Agitation was needed frequently to have the calcium sulfate and activator dissolve thoroughly. The temperature then was raised to 300°–320°C to evaporate the sulfuric acid with proper ventilation. Crystals of calcium sulfate doped with dysprosium or thulium were observed to grow with the progress of evaporation of sulfuric acid.

Single crystals, 0.5–2.0 mm long, were obtained after standing for several hours. The temperature then was turned down to about 200°C, and the crystals immediately were transferred into a platinum crucible and placed in an oven for a heat treatment at 700°C for about 5–6 hours in order to thoroughly evaporate any remaining sulfuric acid.

After cooling, the crystals were ground in a mortar into crystalline powder. The crystals were sieved to obtain an 80 to 200 mesh powder. The phosphor which passed through an 80 mesh sieve and stayed in a 200 mesh sieve was retained. The powder thus obtained was readily activated by radiation.

Table 6. Comparison between LiF-Teflon discs and film badges during 26 November to 24 December 1971

Number	Net doses from:	
	⁶ LiF-Teflon TLD	Film badge
1	BG	BG
2	BG	48 mR
3	23 mR	71 mR
4	BG	27 mR
5	13 mR	34 mR
6	41 mR	119 mR
7	BG	48 mR
8	BG	—
9	23 mR	54 mR
10	26 mR	48 mR
11	BG	41 mR
12	BG	BG
13	30 mR	48 mR
14	16 mR	BG
15	14 mR	BG
16	16 mR	BG
17	12 mR	41 mR
18	18 mR	34 mR
19	BG	41 mR
20	29 mR	48 mR
21	31 mR	41 mR
22	52 mR	54 mR
23	32 mR	71 mR
24	28 mR	66 mR

Average background (BG) = 21 mR/4 weeks

Polyethylene vials containing the phosphor powders, usually good enough for at least two to three readings, first were sealed in polyethylene bags and then wrapped in black paper as a protection against water and light. Bamboo sticks, about 7 cm in diameter and 150 cm long, were used for storing the detectors in a well-protected space about 1 m above the ground. The air had free access to the storage volume above a knot in the bamboo through ventilation holes, and the detectors were protected by a styrofoam layer 4 cm thick and screw-on metal roof carrying warning signs. In addition to $\text{CaSO}_4:\text{Dy}$ and $\text{CaSO}_4:\text{Tm}$ phosphors, $\text{LiF}:\text{Mg}$, Ti phosphor was added since it is comparatively energy independent. Ninety monitoring stations have been distributed around the Tsing Hua Open-pool Reactor (THOR, 1 MW(th)) site as shown in figure 1 in an attempt to obtain representative results as shown in tables 7 and 8.

Similar results were obtained from 30 monitoring posts inside a 40-MW research reactor building at a nearby institute (4). The period of area monitoring was from 23 March to 30 May 1973. It showed an indoor background of 0.67 ± 0.03 mR/day, while the outdoor background (in front of the reactor building) was 0.5 ± 0.03 mR/day. The average radiation level in the reactor bay was 9.80 ± 0.43 mR/MW-

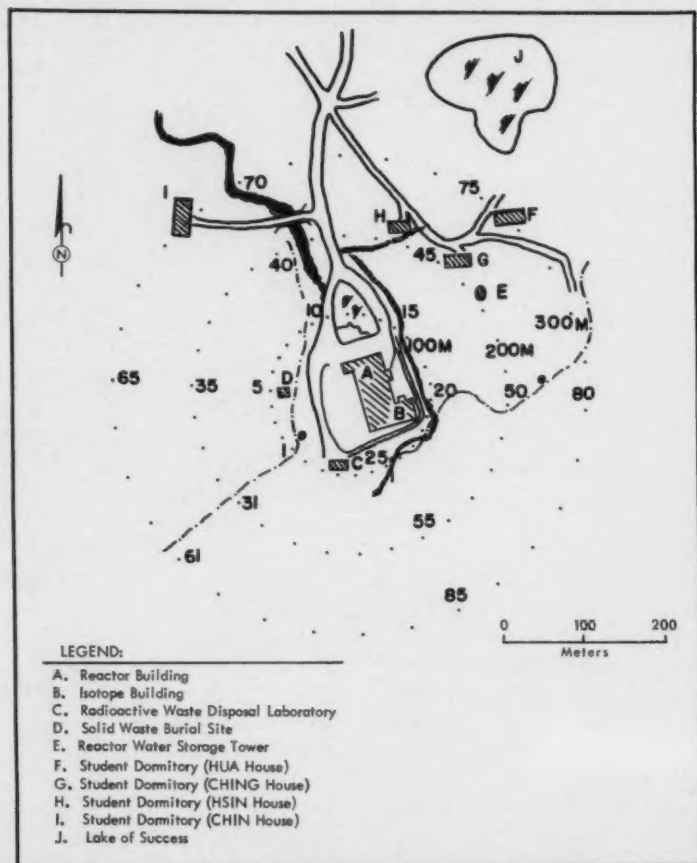


Figure 1. TLD monitoring stations of Taing Hua open-pool reactor site

day or 2.90 ± 0.13 mR/day as monitored by $\text{CaSO}_4:\text{Dy}$ and $\text{CaSO}_4:\text{Tm}$ powders.

Discussion

Though during the half a year monitoring period the LiF-Teflon discs showed a consistently higher dose than the film, a few exceptions did appear in tables 1 through 6. This was attributed to the location of the LiF-Teflon disc in the badge. The disc was supposed to be placed in the open-window area of the badge between the gamma and neutron track film. How-

ever, while being used, a few of the discs had shifted their position to the metal filter portion of the badge.

It is noted that in winter time the readings from both LiF-Teflon disc and film showed more consistent results as shown in tables 5 and 6 due to lower temperature and humidity.

In tables 7 and 8, only the results of monitoring are shown. In fact, the good agreement among the readings of the three different TLD detectors at the same station should be noted. Due to the low sensitivity of LiF, its readings are somewhat less reliable than the $\text{CaSO}_4:\text{Dy}$

Table 7. Results of half a year background gamma monitoring at THOR site from 22 June to 22 November 1972

Number	Average exposure (mR/6 months)	Number	Average exposure (mR/6 months)	Number	Average exposure (mR/6 months)
1	64.3 ± 4.29	31	65.8 ± 3.88	61	54.6 ± 1.31
2	61.4 ± .42	32	63.8 ± 2.52	62	—
3	61.2 ± 1.16	33	58.0 ± 1.72	63	62.6 ± .57
4	61.9 ± 3.95	34	60.5 ± 2.08	64	68.2 ± 1.65
5	50.5 ± 1.05	35	—	65	64.6 ± .87
6	59.2 ± 2.65	36	63.9 ± 9.25	66	56.8 ± 3.78
7	63.4 ± 3.76	37	57.1 ± 1.80	67	55.6 ± 1.00
8	67.3 ± 1.93	38	61.4 ± .96	68	59.2 ± 1.80
9	59.0 ± 2.96	39	61.2 ± 2.36	69	59.3 ± 3.11
10	55.3 ± 2.31	40	—	70	62.5 ± 2.52
11	61.9 ± 2.44	41	59.9 ± 1.00	71	60.4 ± 1.74
12	60.6 ± 2.02	42	68.2 ± 2.48	72	57.5 ± 1.61
13	60.2 ± 3.00	43	60.9 ± .93	73	59.8 ± 2.37
14	51.1 ± 9.01	44	68.5 ± 6.33	74	53.6 ± 3.50
15	—	45	72.2 ± 3.59	75	56.1 ± 1.06
16	60.0 ± 1.04	46	60.2 ± 3.82	76	58.3 ± 1.36
17	65.2 ± 6.87	47	62.3 ± 2.19	77	60.9 ± 2.81
18	66.3 ± 4.48	48	62.9 ± 2.49	78	66.0 ± 1.48
19	66.4 ± 7.15	49	60.9 ± .56	79	62.1 ± 1.27
20	76.0 ± 8.80	50	63.0 ± 5.99	80	58.1 ± 3.48
21	71.9 ± 6.21	51	61.8 ± 2.43	81	58.3 ± 1.47
22	62.8 ± 2.60	52	59.4 ± 1.99	82	67.7 ± 1.89
23	70.5 ± 2.08	53	60.9 ± 2.59	83	58.2 ± 2.17
24	72.7 ± 6.20	54	—	84	52.9 ± 2.55
25	81.4 ± 5.73	55	53.7 ± 2.55	85	57.1 ± 2.47
26	1120.5 ± 43.70	56	60.2 ± 5.13	86	53.4 ± .67
27	84.8 ± 3.20	57	—	87	—
28	62.0 ± 6.77	58	—	88	56.0 ± 1.48
29	67.6 ± 7.39	59	70.3 ± 4.87	89	57.5 ± 1.55
30	64.2 ± 1.86	60	57.4 ± 1.61	90	53.2 ± 1.7

Table 8. Results of one year background gamma monitoring at THOR site from 26 November 1972 to 26 November 1973

Number	Average exposure (mR/yr)	Number	Average exposure (mR/yr)	Number	Average exposure (mR/yr)
1	256 ± 5.3	26	250 ± 2.7	64	241 ± 3.0
5	243 ± 2.8	27	228 ± 2.7	65	237 ± .6
6	240 ± 2.1	28	225 ± 3.1	68	230 ± 1.4
8	236 ± 2.9	29	225 ± 3.8	70	236 ± .5
11	250 ± 2.9	30	230 ± 2.4	71	232 ± 1.1
13	266 ± 4.6	32	265 ± 4.0	74	220 ± 2.9
14	250 ± 1.6	36	273 ± 4.0	75	217 ± 3.5
20	269 ± 1.7	37	250 ± 2.2	77	224 ± 3.6
22	254 ± 3.0	38	293 ± 4.8	78	236 ± 1.7
23	259 ± 2.0	48	251 ± 1.9	79	230 ± 3.4
24	251 ± 2.5	49	246 ± 5.1	81	237 ± 2.4
25	243 ± 3.3	63	234 ± 2.3	82	264 ± .7

and $\text{CaSO}_4:\text{Tm}$ results. However, the good agreement between the results of LiF , with its fairly photon energy-independent response characteristics and the other highly-dependent response characteristics indicated a low (if any) contribution of low energy photons to the total dose under the conditions of measurement. Though the soft x-ray component has been reported in environmental monitoring, it has probably been absorbed in the bamboo and the packaging of the detectors. Energy dependent detectors $\text{CaSO}_4:\text{Dy}$ and $\text{CaSO}_4:\text{Tm}$ can, there-

fore, be used in environmental monitoring without the need of energy compensation filters under hot and humid climate conditions.

The monitoring results for 1973 showed much higher doses as compared with the later half of 1972. This was attributed to the nuclear weapons testing at Lop Nor of mainland China and possibly, the French testing at Mururoa Atoll in the South Pacific. All results are expressed with 1-standard deviation. The highest dose 1120.5 ± 43.70 mR (6 months) appearing in monitoring post No. 26 as shown in table 7

was due to the accidental spread of short-lived radioactive wastes. The monitoring results in 1972 showed an average dose ranging from above 100 to 150 mR/yr except for the contaminated area indicated above, and were consistent with data presented by other countries, e.g., 144 mR/yr in the United States (5).

Acknowledgments

The authors wish to thank Dr. Klaus Becker of Oak Ridge National Laboratory for his kind assistance during the development of this monitoring program. The authors also wish to thank Mr. Kua-Lang Pan of the Atomic Power Department of Taiwan Power Company for his preparation and measurement of the TLD samples.

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SECTION I. MILK AND FOOD

Milk Surveillance, December 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 65 sampling stations; 63 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (1). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (2) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of



Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (3) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Research and Development conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (4).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (5). Of the 18 laboratories producing data for the network reports in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The fre-

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable ^a	Warning level ^b	Unacceptable ^c	Total	
Iodine-131: (96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
(438 or 464 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137: (53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89: (29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90: (32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

^a Measured concentration equal to or within 2σ of the known concentration.

^b Measured concentration outside 2σ and equal to or within 3σ of the known concentration.

^c Measured concentration outside 3σ of the known concentration.

quency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (6) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (6). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (3). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (3). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥ 50 pCi/liter;
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥ 20 pCi/liter;
Iodine-131	4-10 pCi/liter for levels <100 pCi/liter;
Cesium-137	4-10% for levels ≥ 100 pCi/liter.
Barium-140	

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports*.

Data reporting format

Table 2 presents the integrated results of

Table 2. Concentrations of radionuclides in milk for December 1973 and 12-month period, January 1973 through December 1973

Sampling location		Type of sample ^a	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average ^b	12-month average	Monthly average ^b	12-month average
UNITED STATES:						
Ala:	Montgomery *	P	NA	5	0	3
Alaska:	Palmer *	P	NA	4	0	1
Ariz:	Phoenix *	P	NA	0	0	0
Ark:	Little Rock *	P	NA	10	0	1
Calif:	Los Angeles *	P	NA	0	0	0
	Sacramento *	P	NA	1	0	0
	San Francisco *	P	NA	0	0	0
	Del Norte	P	13	10	0	6
	Fresno	P	0	1	0	1
	Humboldt	P	3	2	0	1
	Los Angeles	P	0	1	0	2
	Mendocino	P	2	2	0	2
	Sacramento	P	2	2	0	3
	San Diego	P	2	1	0	2
	Santa Clara	P	0	2	0	3
	Shasta	P	2	2	0	2
	Sonoma	P	0	2	0	3
Colo:	Denver *	P	NA	3	0	0
	East	R	NS	NA	NS	22
	Northeast	R	NS	NA	NS	0
	Northwest	R	NS	NA	NS	2
	South Central	R	NS	NA	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NA	NA	4 0	2
	West	R	NS	NA	NS	0
Conn:	Hartford *	P	NA	4	2	
	Central	P	NA		NA	
Del:	Wilmington *	P	NA	5	0	2
D.C:	Washington *	P	NA	3	0	1
Fla:	Tampa *	P	NA	4	21	27
	Central	R	4	5	18	27
	North	R	6	6	16	4
	Northeast	R	6	6	22	29
	Southeast	R	6	5	32	48
	Tampa Bay area	P	4	5	31	25
	West	R	9	8	13	9
Ga:	Atlanta *	P	NS	4	NS	5
Hawaii:	Honolulu	P	NA	0	0	0
Idaho:	Idaho Falls *	P	NA	3	0	0
Ill:	Chicago	P	NA	4	0	1
Ind:	Indianapolis *	P	NA	5	0	2
	Central	P	5	6	0	7
	Northeast	P	7	6	0	8
	Northwest	P	7	7	10	9
	Southeast	P	6	6	10	7
	Southwest	P	7	7	0	8
Iowa:	Des Moines *	P	NA	4	0	0
	Des Moines	P	(2)	5	(2)	0
	Iowa City	P	5	5	0	0
	LeMars	P	5	6	0	0
	Little Cedar	P	3	4	NS	2
Kans:	Wichita *	P	NA	5	0	1
	Coffeyville	P	3	6	0	7
	Dodge City	P	3	4	0	6
	Falls City, Nebr.	R	NS	6	NS	5
	Hays	P	3	6	0	5
	Kansas City	P	6	5	0	8
	Topeka	P	6	7	0	5
	Wichita	P	4	6	0	6
Ky:	Louisville *	P	NA	5	0	2
La:	New Orleans *	P	NA	7	0	1
Maine:	Portland *	P	NA	5	0	15
Md:	Baltimore *	P	NA	6	0	3
Mass:	Boston	P	NA	7	0	10
Mich:	Detroit *	P	NA	6	0	3
	Grand Rapids *	P	NA	7	0	1
	Bay City	P	5	9	0	1
	Charlevoix	P	14	9	0	1
	Detroit	P	9	6	0	0
	Grand Rapids	P	11	9	0	2
	Lansing	P	8	10	0	3
	Marquette	P	9	9	5	8
	Monroe	P	14	12	0	1
	South Haven	P	11	11	0	3
Minn:	Minneapolis *	P	NA	7	0	1
	Bemidji	P	6	7	0	0
	Duluth	P	14	16	0	18
	Fergus Falls	P	6	7	0	0
	Little Falls	P	9	17	0	0
	Mankato	P	5	5	0	0
	Marshall	P	3	3	0	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for December 1973 and 12-month period, January 1973 through December 1973—continued

Sampling location		Type of sample ^a	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average ^b	12-month average	Monthly average ^b	12-month average
	Minneapolis	P	9	9	0	0
	Rochester	P	NS	6	NS	0
Minn:	Jackson	P	NA	8	0	6
Mo:	Kansas City	P	NA	4	0	0
	St. Louis	P	NA	7	0	1
Mont:	Helena	P	NA	2	0	0
Nebr:	Omaha	P	NA	4	0	0
Nev:	Las Vegas	P	NA	4	0	0
N.H:	Manchester	P	NA	8	0	8
N.J:	Trenton	P	NA	5	0	2
N. Mex:	Albuquerque	P	NA	0	0	0
N.Y:	Buffalo	P	NA	4	0	3
	New York City	P	NA	5	0	3
	Syracuse	P	NA	6	0	1
	Albany	P	4 (3)	5	0	0
	Buffalo	P	5	7	16	11
	Massena	P	2	7	0	0
	New York City	P	NS	6	NS	0
	Syracuse	P	NA	7	0	5
N.C:	Charlotte	P	NA	7	0	0
N. Dak:	Minot	P	NA	5	0	3
Ohio:	Cincinnati	P	NA	6	0	2
	Cleveland	P	NA	3	0	0
Okla:	Oklahoma City	P	NA	3	0	1
Oreg:	Portland	P	NA	NA	40	4
	Baker	P	NA	NA	40	0
	Coos Bay	P	NA	NA	40	2
	Eugene	P	NA	NA	40	0
	Medford	P	NA	NA	40	0
	Portland composite	P	NA	NA	40	2
	Portland local	P	NA	NA	40	0
	Redmond	P	NA	NA	40	0
	Tillamook	P	NA	NA	40	0
Pa:	Philadelphia	P	NA	5	0	2
	Pittsburgh	P	NA	8	0	3
	Dauphin	P	3	4	0	0
	Erie	P	6	6	0	0
	Philadelphia	P	6	3	0	1
	Pittsburgh	P	3	5	0	0
R.I:	Providence	P	NA	5	0	6
S.C:	Charleston	P	NA	6	0	5
	Chapin	R	NA	NA	NA	NA
	Clemson	R	NA	NA	NA	NA
	Columbia	R	NA	NA	NA	NA
	Fairfield	R	NA	NA	NA	NA
	Hartsville-02	R	NA	NA	NA	NA
	Hartsville-03	R	NA	NA	NA	NA
	Lee County	R	NA	NA	NA	NA
	Oconee County	R	NA	NA	NA	NA
	Pickens	R	NA	NA	NA	NA
	Williston	R	NA	NA	NA	NA
	Winnabow	R	NA	NA	NA	NA
S. Dak:	Rapid City	P	NA	5	0	1
Tenn:	Chattanooga	P	NA	6	0	2
	Knoxville	P	NA	0	0	0
	Memphis	P	NA	6	0	2
	Chattanooga	P	NA	8	11	3
	Clinton	R	NA	4	0	3
	Fayetteville	R	NA	7	15	4
	Kington	R	NA	6	0	0
	Knoxville	P	NA	3	0	0
	Lawrenceburg	R	NA	6	NS	6
	Nashville	P	NA	3	NS	0
	Pulaski	R	NA	6	0	0
	Sequoyah	R	NA	9	NS	0
Tex:	Austin	P	NA	0	0	0
	Dallas	P	NA	3	0	0
Utah:	Salt Lake City	P	NA	2	0	1
Vt:	Burlington	P	NA	4	0	5
Va:	Norfolk	P	NA	6	0	2
Wash:	Seattle	P	NA	2	0	0
	Spokane	P	NA	5	0	0
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	4
	Longview	R	6	4	12	1
	Sandpoint, Idaho	R	7	5	0	0
	Skagit County	R	NA	6	0	2
W. Va:	Charleston	P	NA	4	0	1
Wisc:	Milwaukee	P	NA	4	0	1
Wyo:	Laramie	P	NA	1	0	1

See footnotes at end of table.

Table 2. Concentration of radionuclides in milk for December 1973 and 12-month period, January 1973 through December 1973—continued

Sampling location		Type of sample ^a	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average ^b	12-month average	Monthly average ^b	12-month average
CANADA:						
Alberta:	Calgary	P	4	4	2	8
	Edmonton	P	4	5	9	12
British Columbia:	Vancouver	P	5	6	14	13
Manitoba:	Winnipeg	P	3	4	11	10
New Brunswick:	Moncton	P	6	7	8	9
Newfoundland:	St. John's	P	10	13	11	16
Nova Scotia:	Halifax	P	6	7	9	10
Ontario:	Ottawa	P	4	4	9	6
	Sault Ste. Marie	P	8	9	15	17
	Thunder Bay	P	5	6	10	11
	Toronto	P	6	4	7	7
	Windsor	P	3	2	8	6
Quebec:	Montreal	P	5	5	6	7
	Quebec	P	8	8	11	12
Saskatchewan:	Regina	P	4	5	8	8
	Saskatoon	P	6	5	3	7
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal ^c	P	NS	0	NS	13
Chile:	Santiago	P	0	0	0	0
Colombia:	Bogota	P	0	1	0	0
Ecuador:	Guayaquil	P	0	1	0	0
Jamaica:	Montego Bay	P	NS	2	NS	23
Puerto Rico:	San Juan ^c	P	NA	2	0	2
Venezuela:	Caracas	P	0	1	0	2
PMN network average ^e			NA	4	0	3

^a P, pasteurized milk

R, raw milk.

^b When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a month period, the number of samples in the monthly average is given in parentheses.

^c Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

^d The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

^e This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote ^c.

NA, no analysis.

NS, no sample collected.

the international, national, and State networks discussed earlier. Column 1 lists all the stations which are reported routinely in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used

for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups,

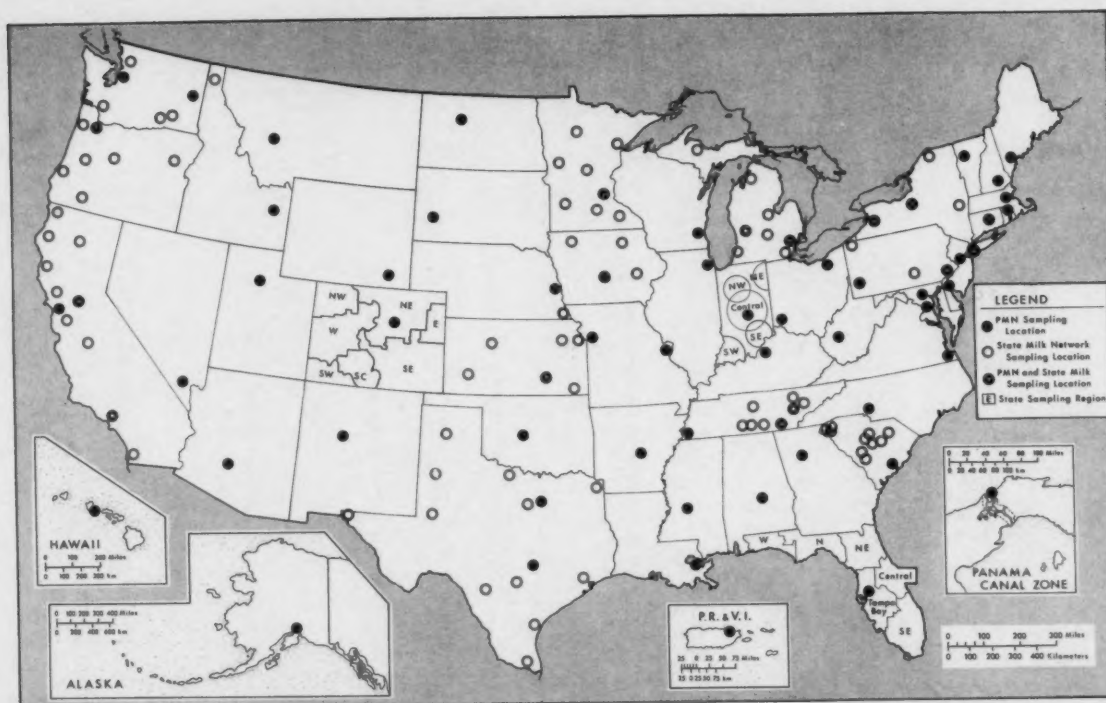


Figure 2. State and PMN milk sampling stations in the United States

averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for December 1973 and the 12-month period, January 1973 to December 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for December 1973 were below the respective practical reporting levels.

Strontium-90 monthly averages ranged from 0 to 14 pCi/liter in the United States for December 1973 and the highest 12-month average was 17 pCi/liter (Little Falls, Minn.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 38 pCi/liter in the United States for December 1973, and the highest 12-month average was 48 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Radiologic Health Section
Environmental Control Component
California Department of Health

Radiation Protection Bureau
Canadian Department of National Health
and Welfare

Radiological Health Section
Division of Occupational and Radiological
Health

Colorado Department of Health
Laboratory Division

Connecticut Department of Health
Radiological and Occupational Health Section
Department of Health and Rehabilitative
Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental
Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina Department of Health and
Environmental Control

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Unit
Health Services Division
Washington Department of Social and Health
Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
Carbon-14 in Total Diet and Milk	1972-1973	November 1973
Institutional Diet	April-June 1973	March 1974
Strontium-90 in Tri-City Diets	1972	December 1973

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (1). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher

concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence¹ of strontium-90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1970	April 1974
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1971	February 1973
Minnesota	July 1971-June 1972	March 1974
New York	July-December 1971	August 1973
North Carolina	1968-1970	September 1972
Radiostrontium in Tap Water, HASL	January-December 1972	December 1973
Tritium Surveillance System	April-June 1973	October 1973
Washington	July 1970-June 1971	August 1973

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ERAMS Surface and Drinking Water Components, July–September 1973

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973, was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

Present network

The ERAMS Surface and Drinking Water Components are an expansion of the previous Tritium Surveillance System which was operated by the Office of Radiation Programs

from 1970 through June 1973. The Drinking Water Component consists of 76 quarterly drinking water samples taken from major population centers and selected nuclear facility environs (figure 1). The analyses include (a) tritium on a quarterly basis, (b) gamma scan, gross alpha and gross beta radioactive measurements annually with radium-226 and strontium-90 measurements if the gross alpha or gross beta radioactivity exceed 3 or 10 pCi/liter, respectively, and (c) an annual composite for plutonium-238 and -239 on 19 selected sampling locations. The Surface Water Component consists of 55 quarterly surface water

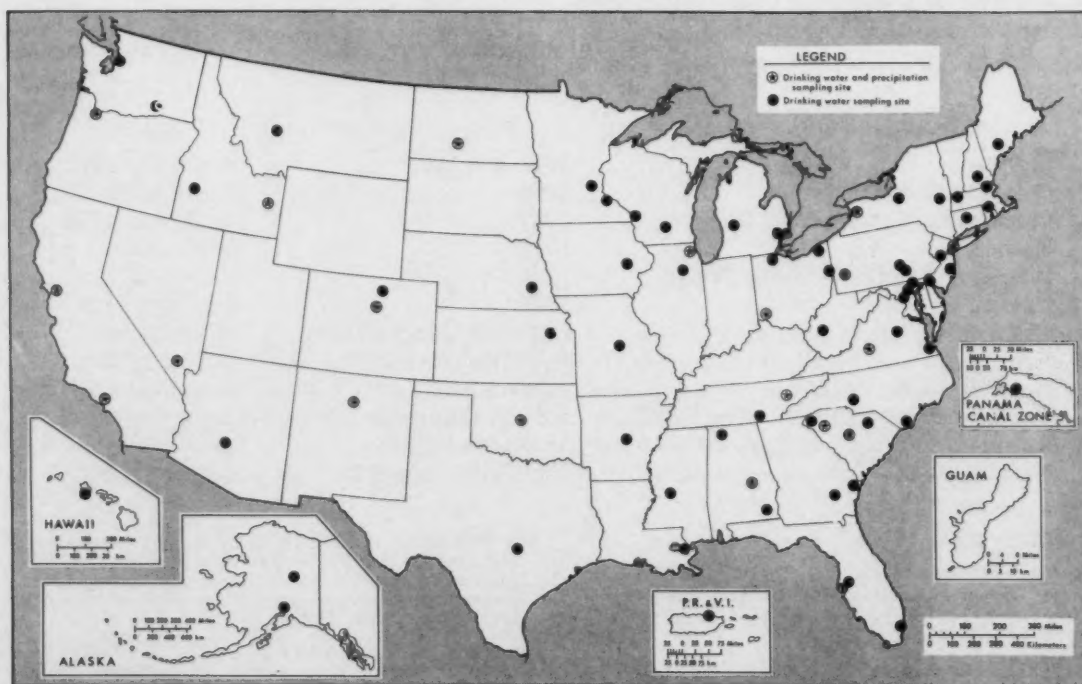


Figure 1. ERAMS drinking water component and precipitation sampling locations

samples downstream from nuclear facilities or at a background station (figure 2). The location of the sampling sites was based on all nuclear facilities that were operating, being constructed, or planned through 1976. Tritium analyses are performed quarterly and gamma scans annually. In addition to these components of ERAMS, precipitation samples will be collected at 19 selected locations (figure 1) and tritium measurements are performed on the monthly composite from each station. These 19 locations correspond to air and drinking water sampling locations selected for plutonium analyses. Plutonium-238 and -239 analyses are performed annually on precipitation samples collected in April when elevated levels of rainfall are expected.

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the Drinking Water Component stations for July–September 1973. The average tritium concentration was 0.3 nCi/liter.

In previous articles on the Tritium Surveillance System, the reported dose equivalent from tritium in body water have been based on a relationship derived by Moghissi and Porter (1). Their relationship assumed a quality factor of 1.7 for tritium beta rays based on a 1966 ICRP recommendation (2). Recently, the NCRP has recommended a quality factor of 1 for tritium beta rays (3) and this recommendation has been adopted for this and subsequent reports. Following the notation adopted by the ICRU (4) substitution of a quality factor of 1 in Moghissi and Porter calculations yields:

$$\dot{H} \text{ (mrem/year)} = 0.1C \text{ (nCi/liter)}$$

Where \dot{H} is the dose equivalent rate and C represents the tritium concentration in body water in nCi/liter.

It can be assumed for the purpose of calculating dose to members of the population that if the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also if that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

Table 1. ERAMS Drinking Water Component, July–September 1973

Location	Date collected (1973)	Tritium concentration ^a (nCi/liter $\pm 2\sigma$) ^b
Ala: Dothan	NS	
Montgomery	7/17	0
Muscle Shoals	NS	
Alaska: Anchorage	7/2	0.4
Fairbanks	7/2	.6
Ark: Little Rock	7/3	0
Calif: Berkeley	7/5	0
Los Angeles	7/5	.3
C. Z: Ancon	7/9	0
Colo: Denver	7/20	.7
Platteville	NS	
Conn: Hartford	7/2	.3
Del: Wilmington	NS	
D.C: Washington	7/20	.4
Fla: Miami	7/2	0
Tampa	NS	
Ga: Baxley	8/14	0
Savannah	8/8	5.6
Hawaii: Honolulu	7/23	.2
Idaho: Boise	7/2	.3
Idaho Falls	8/10	.3
Ill: Chicago	NS	
Morris	NS	
Iowa: Palo	NS	
Kans: Topeka	7/2	0
La: New Orleans	7/11	.4
Maine: Augusta	7/2	.2
Md: Baltimore	7/2	0
Conowingo	NS	
Mass: Lawrence	7/2	.2
Rowe	9/18	.2
Mich: Detroit	NS	
Grand Rapids	9/10	0
Minn: Minneapolis	7/3	.4
Red Wing	9/19	0
Miss: Jackson	7/2	0
Mo: Jefferson City	7/3	0
Mont: Helena	7/3	.5
Nebr: Lincoln	7/6	.4
Nev: Las Vegas	7/2	.7
N.H: Concord	7/2	.4
N.J: Trenton	7/2	.3
Waretown	8/14	.2
N. Mex: Santa Fe	7/3	.5
N.Y: Albany	NS	
Buffalo	7/7	.3
New York City	7/2	0
Syracuse	NS	
N.C: Charlotte	9/14	.2
Wilmington	9/28	.3
N. Dak: Bismarck	7/23	0
Ohio: Cincinnati	7/2	.3
East Liverpool	NS	
Painesville	7/2	.3
Toledo	NS	
Okla: Oklahoma City	7/3	0
Oreg: Portland	7/3	0
Pa: Columbia	NS	
Harrisburg	7/2	0
Pittsburgh	NS	
P.R: San Juan	7/6	0
R.I: Providence	7/3	0
S.C: Anderson	9/14	.8
Columbia	7/2	.4
Hartsville	* 10/2	0
Seneca	* 10/2	.3
Tenn: Chattanooga	8/3	.4
Knoxville	8/6	0
Tex: Austin	7/2	0
Va: Doxwell	NS	
Lynchburg	NS	
Norfolk	NS	
Wash: Richland	NS	.2
Seattle	7/3	0
Wisc: Genoa	9/18	0
Madison	7/2	.2
Average		0.3

^a The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.

^b The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

* Sample collected late.

NS, no sample.

Table 2. ERAMS Surface Water Component, July-September 1973

Location		Water source	Facility	Collection date (1973)	Concentration ^a (nCi/liter $\pm 2\sigma$) ^b
Ala:	Decatur	Tennessee River	Browns Ferry, Sequoyah & Oak Ridge	7/ 6	0.3
	Gordon	Chattahoochee River	Joseph M. Farley	NS	
Ark:	Morrilton	Arkansas River	Arkansas Nuclear One	8/14	.2
Calif:	Clay Station	Folsom S. Canal	Rancho Seco	NS	
	Diablo Canyon	Pacific Ocean	Diablo Canyon	NS	
	Eureka	Humboldt Bay	Humboldt Bay	NS	
	San Onofre	Pacific Ocean	San Onofre	NS	
Colo:	Greely	South Platte River	Fort St. Vrain	7/24	.8
Conn:	East Haddam	Connecticut River	Haddam Neck & Vermont Yankee	7/24	.4
	Waterford	Long Island Sound	Millstone	7/25	0
Fla:	Crystal River	Gulf of Mexico	Crystal River	7/25	0
	Ft. Pierce	Atlantic Ocean	St. Lucie	9/11	0
	Homestead	Biscayne Bay	Turkey Point	7/ 8	0
Ga:	Baxley	Altamaha River	Edwin T. Hatch	8/14	0
Idaho:	Buhl	Snake River	National Reactor Testing Station	7/ 6	0
Ill:	Moline	Mississippi River	Quad-Cities, Genoa, Prairie Island & Monticello	NS	
	Morris	Illinois River	Dresden & Argonne	7/11	.4
	Zion	Lake Michigan	Zion	NS	
Iowa:	Palo	Cedar River	Duane Arnold	NS	
La:	New Orleans	Mississippi River	(Several)	7/ 2	.4
Maine:	Wiscasset	Montswey Bay	Maine Yankee	9/11	0
Md:	Conowingo	Susquehanna River	Peach Bottom & Three Mile Island	7/17	.6
	Lusby	Chesapeake Bay	Calvert Cliffs	7/23	.4
Mass:	Plymouth	Plymouth Bay	Pilgrim	8/ 8	.4
	Rowe	Deerfield River	Yankee	7/ 9	.3
Mich:	Bridgman	Lake Michigan	Donald C. Cook	9/19	.4
	Charlevoix	Lake Michigan	Big Rock Point	7/ 6	.2
	Monroe	Lake Erie	Enrico Fermi	7/ 9	.5
	South Haven	Lake Michigan	Palisades	7/10	.2
Minn:	Monticello	Mississippi River	Monticello	7/ 6	.5
	Red Wing	Mississippi River	Prairie Island & Monticello	9/12	.4
Nebr:	Rulo	Missouri River	Fort Calhoun & Cooper	7/11	.6
Nev:	Boulder City	Colorado River	Background	7/ 3	.7
N.J:	Bayside	Delaware River	Salem	7/16	.2
	Oyster Creek	Toms River	Oyster Creek	8/14	.3
N.Y:	Ossining	Hudson River	Indian Point	7/ 9	.2
	Oswego	Lake Ontario	Nine Mile Point, James A. Fitzpatrick & R. E. Ginna	7/10	.5
N.C:	Poughkeepsie	Hudson River	Background	7/11	.3
	Charlotte	Catawba River	Wm. B. McGuire	7/ 2	.2
Ohio:	Southport	Atlantic Ocean	Brunswick	NS	
	Oak Harbor	Lake Erie	Davis-Besse	NS	
Oreg:	Westport	Columbia River	Trojan & Hanford	NS	
S.C:	Allendale	Savannah River	Savannah River Plant & Oconee	9/26	4.8 \pm .3
	Hartsville	Lake Robinson	H. B. Robinson	7/ 5	.7
Tenn:	Daisy	Tennessee River	Sequoyah & Oak Ridge	8/24	.5
	Kingston	Clinch River	Oak Ridge	7/11	1.0
Tex:	El Paso	Rio Grande	Los Alamos	7/ 2	.3
Vt:	Vernon	Connecticut River	Vermont Yankee	7/ 2	.2
Va:	Mineral	North Anna River	North Anna	NS	
	Newport News	James River	Surry	7/16	0
Wash:	Northport	Columbia River	Background	8/13	.3
	Richland	Columbia River	Hanford	7/ 5	.6
W. Va:	Wheeling	Ohio River	Shippingport & Beaver Valley	7/ 6	.3
Wisc:	Two Creeks	Lake Michigan	Point Beach & Kewaunee	7/16	.4
	Victory	Mississippi River	Genoa, Prairie Island & Monticello	7/ 5	.3
Average					0.4

^a The minimum detection limit for all samples is 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.

^b The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted. NS, no sample.

The highest individual concentration of tritium observed in drinking water was 5.6 nCi/liter during the third quarter. This corresponds to a dose of 0.6 mrem/yr.

The tritium concentrations for the Surface Water Component samples are given in table 2. The highest tritium concentration was 4.8 nCi/liter for the quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentra-

tion corresponds to a dose of 0.5 mrem/yr.

The monthly analyses for tritium in precipitation samples at the selected stations are shown in table 3.

Other coverage in *Radiation Data and Reports*:

Period	Issue
July-September 1972	February 1973
October-December 1972	May 1973
January-March 1973	July 1973
April-June 1973	October 1973

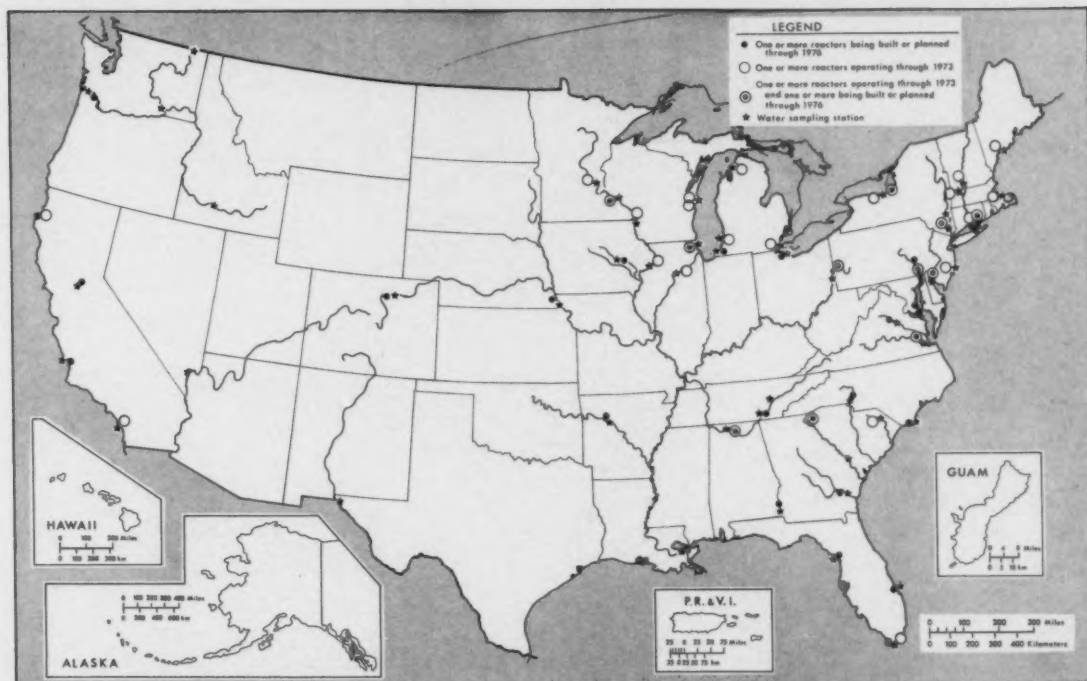


Figure 2. ERAMS surface water component sampling locations

Table 3. Tritium concentration in precipitation
July-September 1973

Location	Tritium concentration* (nCi/liter $\pm 2\sigma$)		
	July	August	September
Aia: Montgomery.....	0.7	0	0
Calif: Berkeley.....	NS	NS	0
Calif: Los Angeles.....	NS	NS	NS
Colo: Denver.....	.7	.3	0
Idaho: Idaho Falls.....	NS	NS	NS
Ill: Chicago.....	NS	NS	NS
Nev: Las Vegas.....	NS	NS	NS
N. Mex: Santa Fe.....	.4	0	NS
N.Y: Buffalo.....	NS	NS	NS
N.Y: New York City.....	NS	NS	NS
N. Dak: Bismarck.....	.4	.4	.2
Ohio: Cincinnati.....	NS	NS	NS
Okl: Oklahoma City.....	NS	NS	NS
Oreg: Portland.....	NS	NS	NS
Pa: Pittsburgh.....	NS	NS	NS
S.C: Anderson.....	NS	NS	NS
Tenn: Knoxville.....	1.0	.8	.4
Va: Lynchburg.....	NS	NS	NS

* The minimum detection limit for these samples is 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero. The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

NS, no sample.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of pro-

grams are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports*.

<u>Network</u>	<u>Period</u>	<u>Issue</u>
Fallout in the United States and other areas, <i>HASL</i>	1971	August 1973
Krypton-85 in air	July 1970-1972	March 1974
Surface air sampling program, 80th Meridian Network, <i>HASL</i>	1971	September 1973

*Eastern Environmental Radiation Facility
Environmental Protection Agency*

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during December 1973.

The Office of Radiation Programs is in the process of modifying the air program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.



Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, December 1973

Station location*	Number of samples	Gross beta radioactivity (pCi/m ³)						Precipitation	
		5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
		Maximum	Minimum	Average ^b	Maximum	Minimum	Average ^b	Depth (mm)	Total deposition (nCi/m ²)
Ala: Montgomery.....	8	1	0	0	0.02	<0.01	0.02	74	0.17
Calif: Berkeley.....	8	1	0	0	.03	.01	.02	29	.04
Calif: Los Angeles.....	8	1	0	1	.07	.02	.05		
Colo: Denver.....	8	1	0	0	.05	.03	.04	8	.08
Ind: Indianapolis.....	11	4	0	1	.05	.01	.03		
Nev: Las Vegas.....	7	2	0	1	.23	<.01	.05		
N. Mex: Santa Fe.....	5	1	0	1	.05	.03	.04		
N.Y: Buffalo.....	8	0	0	0	.04	.02	.03	13	.01
N. Dak: Bismarck.....	4	0	0	0	.06	<.01	.03	9	.04
Ohio: Columbus.....	7	1	0	0	.04	<.01	.03		
Oreg: Portland.....	20	0	0	0	.03	<.01	.01		
Pa: Harrisburg.....	19	2	0	1	.06	.02	.03		
S.C: Columbia.....	8	2	0	0	.08	.01	.04	127	.50
Network summary.....	121	4	0	0	0.23	<0.01	0.03	43	0.14

* The remaining stations are on standby status.

^b The monthly average is calculated by weighting the estimates of individual air samples with length of sampling period.

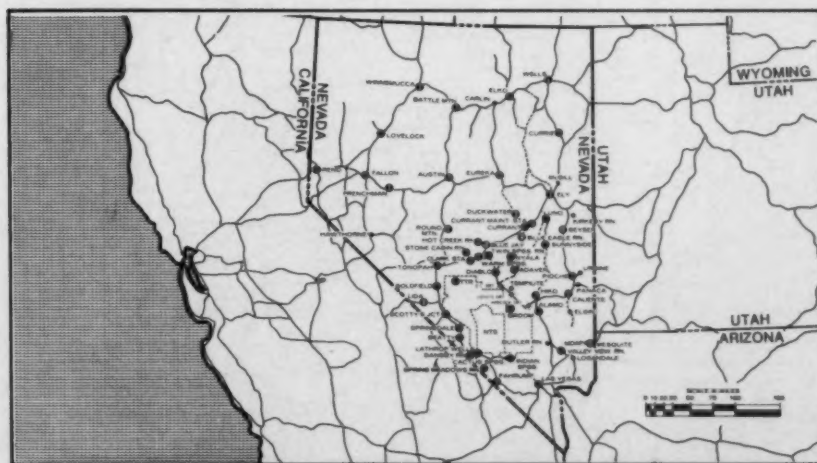


Figure 2. NERC-LV Air Surveillance Network stations in Nevada

2. Air Surveillance Network December 1973

*National Environmental Research Center—
Las Vegas
Environmental Protection Agency*

The Air Surveillance Network (ASN)^a, operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 Western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are

^a The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

operated continuously with filters being exchanged over periods generally ranging from 48 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports*.

Results

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m³. For reporting purposes, concentrations less than 1.0 pCi/m³ are reported to 1 significant figure, and those equal to or greater than 1.0 pCi/m³ are reported to 2 significant figures. For averaging purposes, individual concentration values less than the minimum detectable concentration (~0.03 pCi/m³ for a 700 m³ sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off conventions are indicated as follows:



Figure 3. NERC-LV Air Surveillance Network stations outside Nevada

Concentration (pCi/m ³)	Reported value of concentration above MDC (pCi/m ³)	Reported value of concentration below MDC (pCi/m ³)
<0.05	<0.1	<0.1
≥ .05, <.15	.1	< .1
≥ .15	As calculated and rounded	< calculated MDC

As shown by table 2, the highest gross beta concentration at continuously operated stations within the network was 0.7 pCi/m³ at Warm Springs, Nev. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during December.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentrations in air, December 1973

Location		Number of samples	Concentration (pCi/m ³)		
			Maximum	Minimum	Average *
Ariz:	Kingman.....	13	0.2	<0.1	0.1
	Seligman.....	13	.1	<.1	.1
Calif:	Baker.....	12	.2	<.1	.1
	Barstow.....	13	.1	<.1	.1
	Bishop.....	13	.2	<.1	.1
	Death Valley Junction.....	13	.2	<.1	.1
	Furnace Creek.....	13	.2	<.1	.1
	Lone Pine.....	4	.2	<.1	.1
	Needles.....	8	.2	<.1	.1
	Ridgecrest.....	13	.2	<.1	.1
	Shoshone.....	13	.1	<.1	.1
	Alamo.....	13	.2	<.1	.1
Nev:	Austin.....	13	.2	<.1	.1
	Beatty.....	13	.1	<.1	.1
	Blue Eagle Ranch (Currant).....	13	.2	<.1	.1
	Blue Jay.....	13	.1	<.1	.1
	Caliente.....	13	.2	<.1	.1
	Currant Ranch.....	12	.1	<.1	.1
	Diablo.....	13	.1	<.1	.1
	Duckwater.....	10	.1	<.1	.1
	Ely.....	13	.1	<.1	<.1
	Eureka.....	13	.1	<.1	.1
	Fallini's Twin Springs Ranch.....	13	.2	<.1	.1
	Geyser Ranch (Pioche).....	10	.2	<.1	.1
	Goldfield.....	11	.2	<.1	.1
	Groom Lake.....	9	.1	<.1	.1
	Hiko.....	13	.2	<.1	.1
	Indian Springs.....	13	.1	<.1	.1
	Las Vegas.....	14	.3	<.1	.1
	Lathrop Wells.....	13	.1	<.1	.1
	Lida.....	13	.1	<.1	.1
	Lund.....	13	.1	<.1	.1
	Mesquite.....	13	.1	<.1	.1
	Nyala.....	13	.2	<.1	.1
	Pahrump.....	13	.1	<.1	.1
	Pioche.....	11	.1	<.1	.1
	Round Mountain.....	13	.1	<.1	.1
	Scotty's Junction.....	11	.1	<.1	.1
	Stone Cabin Ranch.....	13	.1	<.1	.1
	Sunnyside.....	13	.1	<.1	.1
	Tonopah.....	13	.1	<.1	.1
	Tonopah Test Range.....	8	.2	<.1	.1
	Warm Springs.....	9	.7	<.1	.1
	Warm Springs Ranch.....	14	.2	<.1	.1
Utah:	Cedar City.....	10	.1	<.1	.1
	Delta.....	13	.1	<.1	.1
	Garrison.....	13	.1	<.1	.1
	Milford.....	12	.1	<.1	.1
	St. George.....	13	.2	<.1	.1

3. Canadian Air and Precipitation Monitoring Program,³ December 1973

Radiation Protection Bureau
Department of National Health and Welfare

The Radiation Protection Bureau of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Atmospheric Environment Service of the Department of the Environment. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the National Health and Welfare (1-5).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

³ Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for December 1973 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, December 1973

Location	Number of samples	Air surveillance gross beta radioactivity (pCi/m ³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m ²)
Calgary	4	0.04	0.01	0.02	12	0.27
Coral Harbour	4	.04	.01	.03	23	.26
Edmonton	4	.04	.02	.03	9	.40
Ft. Churchill	4	.04	.01	.02	3	21
Fredericton	2	.03	.03	.03	6	.57
Goose Bay	1	.01	.01	.01	4	.38
Halifax	4	.03	.02	.02	8	.53
Inuvik	3	.02	.02	.02	9	.12
Montreal	4	.01	<.01	.01	19	1.20
Moosonee	4	.03	.01	.02	1	.03
Ottawa	3	.02	.01	.01	15	.88
Quebec	3	.02	.01	.01	7	.52
Regina	4	.04	.02	.03	10	.23
Resolute	4	.04	.02	.03	7	.13
St. John's, Nfld	4	.02	.01	.02	NS	NS
Saskatoon	4	.04	.03	.03	6	.23
Sault Ste. Marie	4	.02	.01	.02	9	.70
Thunder Bay	4	.03	.01	.02	11	.95
Toronto	1	.03	.03	.03	18	1.70
Vancouver	4	.01	.01	.01	4	.66
Whitehorse	4	.05	.02	.03	9	.21
Windsor	NS	.01	<.01	.01	10	.39
Winnipeg	2	.01	<.01	.01	12	.32
Yellowknife	3	.03	.02	.02		
Network summary	78	0.05	<0.01	0.02	10	0.51

NS, no sample.



Figure 4. Canadian air and precipitation sampling stations

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4. Pan American Air Sampling Program December 1973

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The December 1973 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, December 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average *
Argentina: Buenos Aires.....	0			
Bolivia: La Paz.....	4	0.03	0.01	0.02
Chile: Santiago.....	17	.04	.01	.02
Colombia: Bogota.....	19	.01	.00	.00
Ecuador: Cuenca.....	12	.03	.00	.01
Guayaquil.....	18	.05	.00	.01
Quito.....	4	.00	.00	.00
Guyana: Georgetown.....	0			
Jamaica: Kingston.....	0			
Peru: Lima.....	6	.01	.00	.01
Trinidad and Tobago: Port of Spain.....	0			
Venezuela: Caracas.....	7	.01	.00	.00
Pan American summary.....	87	0.05	0.00	0.01

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ reported and used in averaging 0.00 pCi/m³.



Figure 5. Pan American Air Sampling Program stations

5. California Air Sampling Program December 1973

Radiologic Health Section California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne par-



Figure 6. California air sampling program stations

ticulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha

Table 5. Gross beta radioactivity in California air December 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average
Bakersfield.....	31	1.03	0.04	0.21
Barstow.....	31	1.01	.06	.30
Berkeley.....	31	.16	.00	.07
El Centro.....	30	.42	.06	.14
Eureka.....	25	.16	.00	.05
Fresno.....	30	.48	.04	.13
Los Angeles.....	28	.27	.01	.12
Redding.....	31	.20	.00	.11
Sacramento.....	26	.17	.00	.06
Salinas.....	31	.61	.03	.15
San Bernardino.....	28	.71	.09	.19
San Diego.....	31	.43	.04	.13
San Luis Obispo.....	31	.67	.04	.13
Santa Rosa.....	31	1.46	.01	.10
Summary.....	415	1.46	0.00	0.14

and beta radioactivity, 72 hours after the end of the collection period. The daily samples then are composited into a monthly sample for gamma spectroscopy and an analysis for stron-

tium-89 and strontium-90. Table 5 presents the monthly gross beta radioactivity in air for December. The monthly sample results are presented quarterly.

6. Mexican Air Monitoring Program July-December 1973

*Instituto Nacional de Energía Nuclear
México, D.F.*

The Radiation Surveillance Network of Mexico is operated by the Instituto Nacional de Energía Nuclear (INEN).

In the Instituto Nacional de Energía Nuclear, the Comité de Seguridad Radiológica (Radiological Security Committee) (CSR) is responsible for radiological protection. The Environmental Radioactivity Section (Sección de Radioactividad Ambiental) of the CSR is in charge of monitoring and measuring environmental radioactive contamination in general, including radiation in mines, uranium milling plant, and the Nuclear Center of Mexico.

Since radioactivity in air particulates have decreased to very low levels in the past few years, the objective of the air monitoring program has been changed from an alert type of network to emphasize dose assessment.

Measurements will continue in the following 6 areas: México City, D.F., Chihuahua, Ensenada, Torreón, Veracruz and Mérida (figure 7). The sampling and analysis procedures were described previously (1).

The maximum, minimum, and average beta radioactivity in surface air from July through December 1973 are presented in table 6. Statistically, it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (2).



Figure 7. Mexican air sampling locations

Table 6. Mexican gross beta radioactivity of airborne particulates, July-December 1973

Station	Gross beta radioactivity (pCi/m ³)					
	July	Aug	Sept	Oct	Nov	Dec
Chihuahua:						
Maximum.....	0.23	0.20	0.17	NS	NS	0.13
Minimum.....	<.03	.04	.04	NS	NS	.06
Average.....	.12	.11	.11	NS	NS	.09
Ensenada:						
Maximum.....	.10	.13	NS	NS	NS	NS
Minimum.....	<.03	.10	NS	NS	NS	NS
Average.....	.06	.11	NS	NS	NS	NS
Mérida:						
Maximum.....	.12	.10	.12	0.15	.13	.14
Minimum.....	.04	.05	.04	.06	.04	.04
Average.....	.09	.07	.06	.09	.07	.10
México, D.F.:						
Maximum.....	NS	.14	.06	.22	.05	NS
Minimum.....	NS	.04	.04	.04	.04	NS
Average.....	NS	.07	.05	.05	(*)	NS
Torreón:						
Maximum.....	.27	.20	.12	.14	.16	.15
Minimum.....	.06	.05	.03	.05	.06	.06
Average.....	.12	.08	.06	.10	.09	.11
Veracruz:						
Maximum.....	.26	.17	.11	.16	.21	.15
Minimum.....	.05	.05	.04	.04	.04	.04
Average.....	.12	.10	.07	.09	.09	.09

* Average not calculated for less than 5 samples.
NS, no sample.

REFERENCES

- (1) INSTITUTO NACIONAL DE ENERGIA NUCLEAR. Mexican air monitoring program, August-December 1970 and January 1971. Radiol Health Data Rep 12:525-528 (October 1971).
- (2) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963-1965. Comision Nacional de Energía Nuclear, Direccion General de Seguridad Radiologica (1966).

7. Plutonium in Airborne Particulates January-March 1973

*Office of Radiation Programs
Environmental Protection Agency*

The Radiation Alert Network (RAN) of the Division of Atmospheric Surveillance, Environmental Protection Agency, routinely collects airborne particulate samples from 11 selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965, and references to the previous results through December 1969 have been published (1).

One-half of each individual air filter from the selected stations is sent to the Eastern Environmental Radiation Facility, Montgomery, Ala. The laboratory analyzes a composite of these samples from each station on a quarterly basis. The results from January-March 1973 are presented in table 7. The minimum detectable activities are 0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Table 7. Plutonium in airborne particulates
January-March 1973

Location	Plutonium-238 (aCi/m ³)	Plutonium-239 (aCi/m ³)	²³⁹ Pu/ ²³⁸ Pu
Alaska: Anchorage-----	(a)	(a)	
Ariz: Phoenix-----	2.3 ± 0.9	19.5 ± 2.6	8 ± 3
Colo: Denver-----	3.1 ± .9	17.8 ± 2.3	6 ± 2
Hawaii: Honolulu-----	1.7 ± .7	10.1 ± 1.6	6 ± 3
La: New Orleans-----	1.0 ± .5	10.3 ± 1.7	10 ± 5
Md: Baltimore-----	1.3 ± .5	8.2 ± 1.3	6 ± 3
N.Y: Buffalo-----	2.0 ± .6	9.4 ± 1.4	5 ± 2
N.C: Gastonia-----	1.8 ± .6	10.4 ± 1.5	6 ± 2
S. Dak: Pierre-----	2.2 ± .7	14.6 ± 2.0	7 ± 2
Tex: Austin-----	2.2 ± .8	20.6 ± 2.4	9 ± 4
Wash: Seattle-----	.6 ± .4	5.3 ± 1.2	9 ± 6

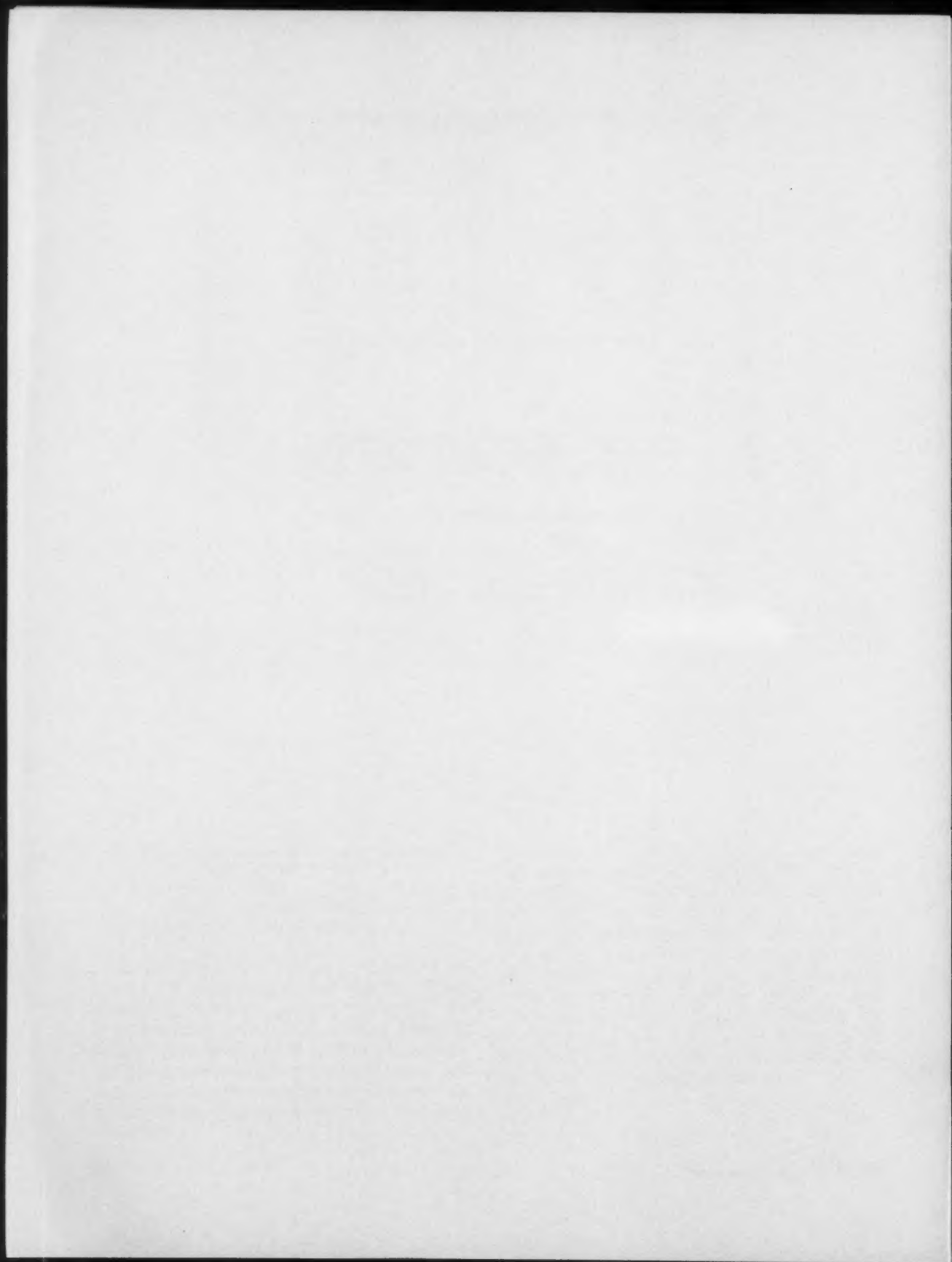
* Insufficient sample volume to obtain detectable levels of plutonium.

REFERENCE

- (1) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April-December 1969. Radiol Health Data Rep 11:552-553 (October 1970).

Other coverage in *Radiation Data and Reports*:

Period	Issue
January-March 1972	December 1972
April-June 1972	January 1973
July-September 1972	March 1973
October-December 1972	June 1973



SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained

from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation stand-

ards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."¹

A summary of the environmental radioactivity data follow for Rocky Flats, the Sandia Laboratories and the Stanford Linear Accelerator Center.

¹Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Rocky Flats Plant² January-December 1971

*Dow Chemical Company
Golden, Colo.*

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission (AEC). Its location, relative to population centers, is shown in figure 1. The basic goal guiding these operations is total containment of radioactive materials. The environmental survey program is designed to assure that radioactive materials released are below the AEC standards.

²Summarized from Environmental Monitoring at Major U.S. Atomic Commission Contractor Sites, Rocky Flats Plant, January-December 1971."

The plant is located about 15 miles northwest of Denver, Colo. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air sampling

To provide further detection and measurement of any accidental release of any contaminated effluents, Rocky Flats maintains an extensive network of continuously operating air sampling devices to monitor contamination levels in the surrounding atmosphere.

Continuous samples are obtained from 12 onsite air sampling stations (figure 2) which sample about 82 cubic meters of air per day

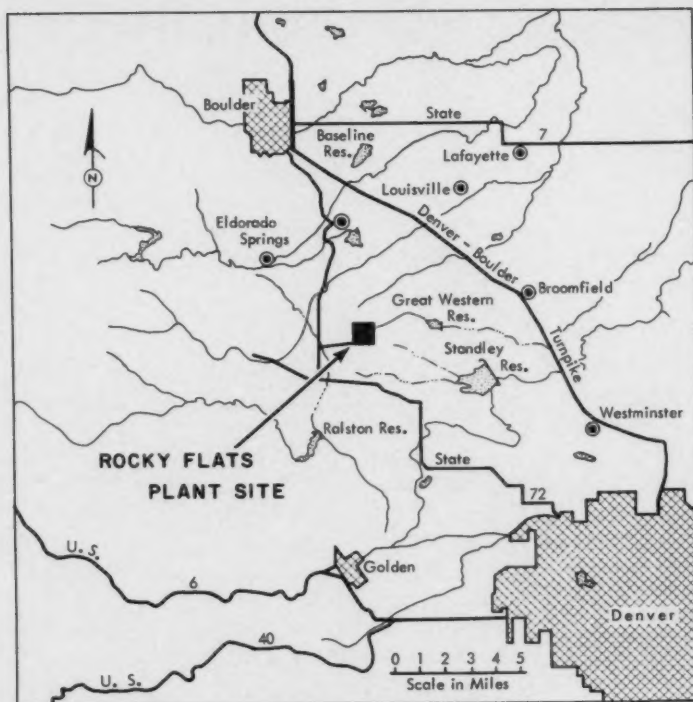


Figure 1. Location of Rocky Flats Plant

(the equivalent of 2 cubic feet per minute). These samples are collected and analyzed daily for total long-lived alpha concentrations (which would include plutonium, uranium, and other long-lived alpha emitters) and specifically for beryllium (figure 2).

Twelve high-volume air samplers are located at a radius of about 2 miles from the plant perimeter (figure 3). These samples are collected on a 4-inch filter paper, which is changed daily, composited and analyzed specifically for plutonium. The 437 composite samples for 1971 represent volumes of over 2 000 000 cubic meters (about 70 000 000 cubic feet) of air actually filtered in 1971.

High-volume samples are also taken weekly from Wagner Site (18, figure 3) and from Coal Creek Canyon (11, figure 3), about 2.5 miles southeast and 3 miles west southwest of

the plant, respectively. For 1971, the 77 samples taken represent volumes of about 17 000 cubic meters of air (nearly 600 000 cubic feet). These were analyzed specifically for plutonium.

Results for the year indicated a maximum of 0.06 pCi/m³. High-volume grab samples were also taken to the east of an asphalt pad covering some contaminated soil (former drum storage area in the southeast corner of the plant site proper). The 180 samples taken in 1971 represent over 40 000 cubic meters of air actually filtered and were analyzed for total plutonium content. The results varied from a single sample maximum of 520 fCi/m³ to a yearly average of 12 fCi/m³.

Nine low-volume air samplers, programmed to sample for 10 minutes of each hour, are located in Boulder, Broomfield, Denver, Coal Creek Canyon, Golden, Lafayette, Westminster,

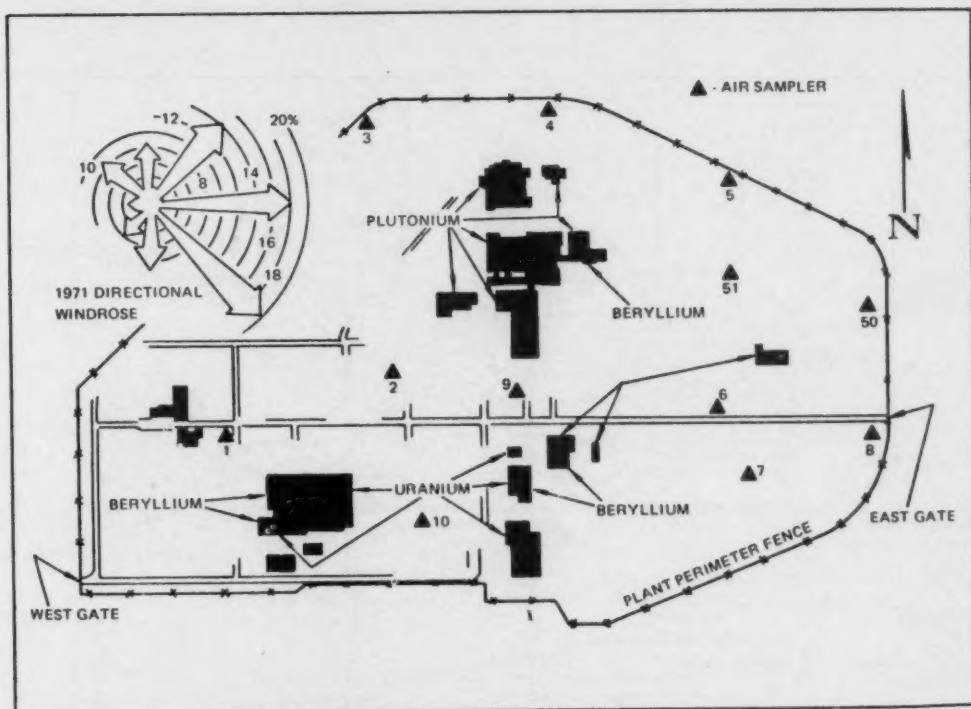


Figure 2. Onsite air sampling locations and material areas, Rocky Flats Plant

Marshall and Wagner (figure 4). These samples are collected weekly and analyzed for total long-lived alpha activity. The low-volume samplers represent about 44 000 cubic meters of air during 1971.

This complex of air samplers produces nearly 10 000 samples per year. These are analyzed to make certain that effluent levels as well as any redistribution effects are kept well below guideline concentrations. Summaries of these results for 1971 are presented in tables 1, 2, 3, and 4. Onsite air samples varied from a maximum average long-lived alpha concentration (1-month average) of 32.2 fCi/m³ with a 12-month average of 4.8 fCi/m³, about 24.0 percent of the standard.

Low-volume, offsite air sample results were also quite low. The programmed samplers indicated a maximum long-lived alpha concentration (1 month average) of 12.3 fCi/m³ with a yearly average of 4.0 fCi/m³, about 60 percent of the guidelines. The high-volume, offsite samplers, much more indicative of chronic exposure levels, revealed much lower concentrations. The maximum (1-month plutonium average) was 4.6 fCi/m³ whereas the average for the year was 0.24 fCi/m³, about 1.2 percent of the guideline.

Data from the air sampling network indicate that the average contaminant concentrations in air effluents from Rocky Flats were below the established standards.

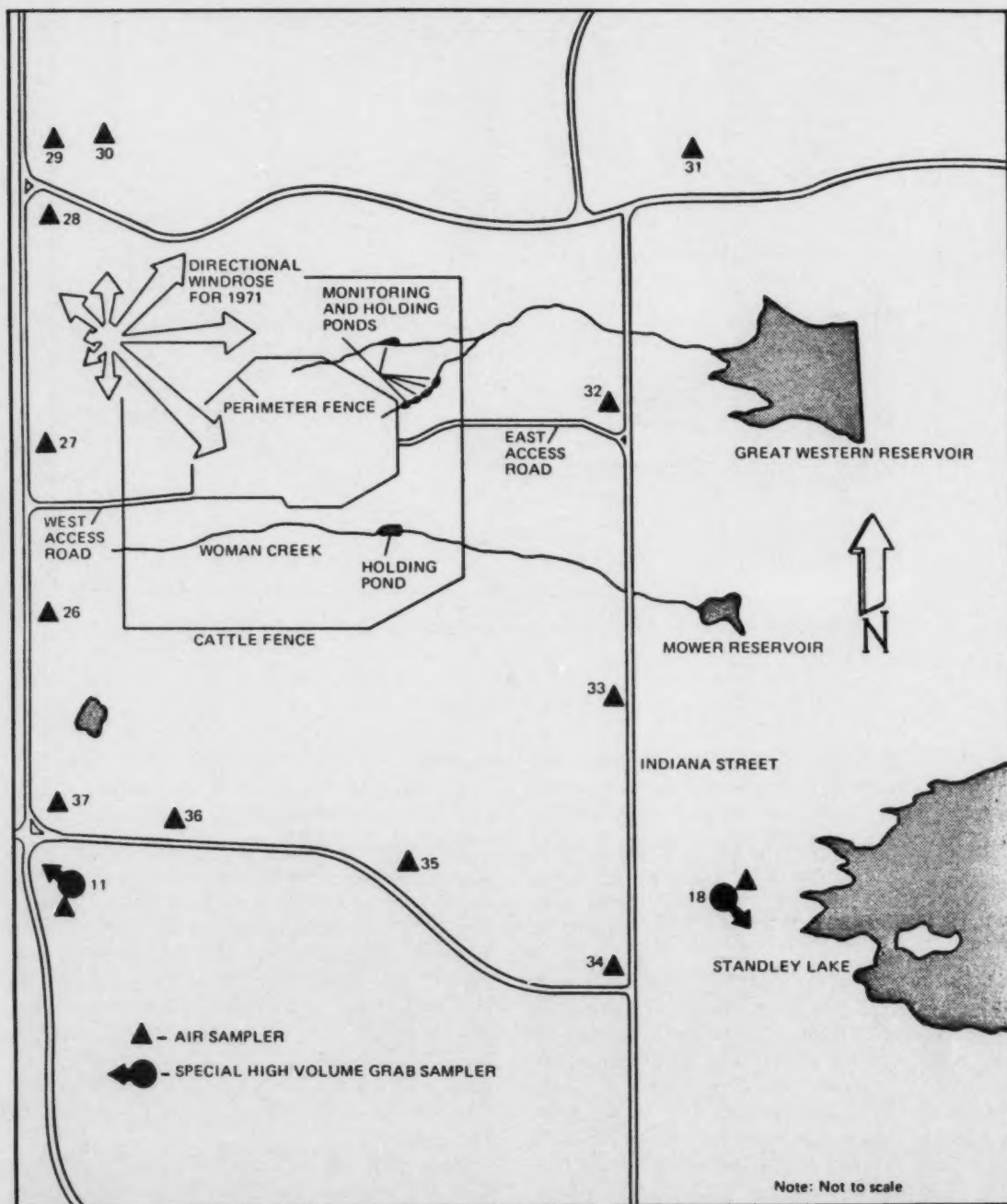


Figure 3. Offsite high-volume environmental air sampling network

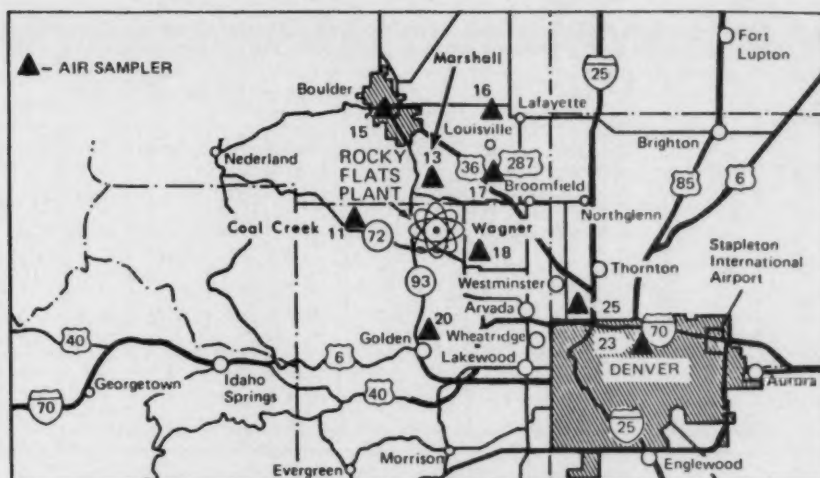


Figure 4. Programmed environmental air sampling network

Table 1. Total long-lived alpha (uranium, plutonium, and naturally occurring alpha emitters) in onsite air samples, Rocky Flats Plant, January-December 1971

Location *	Average concentration (fCi/m ³)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	4.4	3.8	4.5	3.6	5.7	4.7	3.8	4.0	4.5	4.9	3.5	3.5
2	4.5	4.4	3.9	4.6	4.6	2.5	2.5	4.9	3.1	4.4	4.0	4.4
3	3.3	2.8	3.3	5.9	5.2	4.3	5.5	6.6	7.0	5.2	5.0	3.9
4	2.0	4.4	4.7	6.6	4.2	3.6	4.6	4.1	3.5	3.4	3.4	2.2
5	1.7	4.0	3.2	3.6	4.7	5.4	5.3	2.6	3.4	5.8	6.9	3.3
6	3.1	3.0	2.8	3.7	5.2	3.0	14.6	2.0	3.2	2.9	6.8	2.7
7	8.2	6.6	5.4	8.2	4.3	4.3	2.7	3.4	2.2	3.4	1.7	4.3
8	5.8	6.9	7.8	32.2	9.0	8.1	10.5	11.0	5.6	12.8	11.4	6.6
9	4.3	4.0	4.1	3.9	3.6	3.8	4.4	3.6	2.6	2.7	1.3	3.8
10	4.6	5.2	4.1	6.0	4.2	5.6	3.4	3.0	4.0	6.3	4.1	3.5
50	4.2	2.6	4.1	8.5	4.8	7.1	5.3	8.6	6.1	7.6	6.4	3.3
51	4.4	5.1	3.6	6.6	4.6	3.3	2.5	2.0	4.1	5.4	4.4	5.2

1a. Summary of total long-lived alpha in onsite air samples, Rocky Flats Plant, 1971

Location *	Total number of samples	Number of samples less than detectable level	Maximum (fCi/m ³)	Average (fCi/m ³)	Percent of standard ^b
1	242	125	21.8	4.2	21.0
2	239	140	42.0	4.0	20.0
3	244	124	21.8	4.8	24.0
4	243	142	33.3	3.9	19.5
5	244	132	22.8	4.1	20.5
6	244	161	272.3	4.3	21.5
7	244	136	32.2	4.5	22.5
8 ^a	243	81	565.3	10.2	51.5
9	242	147	21.9	3.5	17.5
10	237	125	22.8	4.5	22.5
50	243	120	143.6	5.7	28.5
51	244	135	34.1	4.3	21.5
Yearly summation	2 909	1 568	565	4.8	24.0

^a See figure 2.

^b Applicable standard (soluble plutonium-239) = 20 fCi/m³.

^c This sampler is located within the strongest, most frequent wind vector, and is adjacent to the asphalt pad covering some contaminated soil. The large volumes of dirt thus seen by this sampler may be indicative of resuspension mechanisms. It is worthy of note that this, the highest concentration location, is still only about 50 percent of the applicable standard when stated in terms of yearly averages.

Note: For averaging purposes, all samples below minimum detectable amounts (MDA) were assigned a fractional value (number of samples > MDA divided by total number of analyses) of the appropriate MDA.

Table 2. Total long-lived alpha (uranium, plutonium, and naturally occurring alpha emitters) in offsite low volume programmed air samples, Rocky Flats Plant, January-December 1971

Location ^a	Average concentration (fCi/m ³)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Boulder (15)-----	4.0	4.1	0.5	5.9	7.2	6.1	3.5	8.9	6.0	6.7	6.7	3.9
Broomfield (17)-----	3.2	6.2	5.6	5.1	3.0	2.8	.4	5.4	3.4	.1	3.1	3.8
Coal Creek (11)-----	.1	4.0	2.2	5.6	2.5	3.5	ND	ND	.2	2.4	2.7	2.1
Denver (23)-----	2.0	1.3	8.9	5.0	3.7	4.8	2.8	7.7	5.6	1.8	3.8	2.8
Golden (20)-----	3.1	5.0	5.4	5.7	5.7	ND	ND	.8	10.8	3.8	2.1	1.8
Lafayette (16)-----	7.3	7.2	6.4	8.5	5.7	5.2	3.0	4.3	7.9	3.0	2.1	6.7
Marshall (13)-----	4.8	2.3	ND	ND	2.6	.2	2.0	8.7	3.8	1.5	ND	.2
Wagner (18)-----	2.6	ND	2.9	8.3	9.2	12.3	6.3	7.1	5.5	2.9	2.7	5.0
Westminster (25)-----	2.7	.1	2.7	6.7	.2	7.8	4.9	5.4	1.4	5.0	2.6	6.2

2a. Summary of long-lived alpha concentrations, low-volume programmed samples, 1971

Location ^a	Number of samples	Number of samples less than detectable level	Concentration (fCi/m ³)					
			January-June 1971		July-December 1971		January-December 1971	
			Maximum	Average	Maximum	Average	Average	Percent of standard ^b
Boulder (15)-----	48	23	12.8	5.0	17.4	6.1	5.6	82.9
Broomfield (17)-----	48	32	13.4	4.5	12.8	1.9	3.7	55.2
Coal Creek (11)-----	48	39	12.9	3.0	8.3	1.3	2.1	32.0
Denver (23)-----	47	27	16.0	1.6	9.8	4.1	3.8	57.2
Golden (20)-----	48	34	13.4	4.4	36.8	1.4	4.0	59.3
Lafayette (16)-----	48	23	16.0	7.0	16.3	1.9	6.0	89.5
Marshall (13)-----	47	37	8.2	1.7	7.0	1.9	1.8	27.6
Wagner (18)-----	48	29	19.7	1.3	16.7	1.1	5.7	84.9
Westminster (25)-----	44	35	27.0	3.1	29.8	4.7	3.9	58.4
Summary-----	426	275	27.0	4.3	36.8	3.7	4.0	60.0

^a See figure 4.

^b Applicable standard (unidentified alpha emitters) is 6.7 fCi/m³.
ND, nondetectable.

Dustfall samples

In addition to the air samples obtained, specially designed trays atop all the offsite air stations collect dustfall samples for specific plutonium analysis. In addition, more remote samples are collected from locations near Berthoud and from Castle Rock. Table 5 tabu-

lates these results for the year. All samples are collected on a bimonthly basis, and represent fallout from atmospheric weapons testing, and, of course, any contribution from Rocky Flats. Castle Rock and Berthoud samples are collected to provide an indication of plutonium in dustfall samples from background. The values obtained in this extensive sampling pro-

Table 3. Plutonium concentrations in high volume offsite samples February-December 1971^a

Location ^b	Concentration (fCi/m ³)										
	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
26	0.14	0.20	0.22	0.24	0.19	0.07	0.23	0.12	0.22	0.17	0.03
27	.08	.22	.12	.25	.27	.15	.31	.14	.46	(^c)	.47
28	.17	.19	.12	.20	.27	.13	.29	.33	.12	(^c)	(^c)
29	.19	.16	.11	.23	.41	.28	.33	.22	.14	.17	.24
30	.11	.16	.10	.26	.30	.19	.24	.12	(^c)	(^c)	(^c)
31	.09	.15	.22	.35	.23	.19	.39	.23	.14	.20	.30
32	.19	.33	.16	.23	1.24	.11	.28	.25	1.93	(^c)	.08
33	.25	.30	.20	.33	.30	.18	.26	.21	.09	.13	.22
34	.20	.25	.14	.31	.39	.12	.22	ND	(^c)	(^c)	.17
35	.16	.21	.16	.27	.29	.16	.22	.16	.31	ND	.39
36	.11	.95	.21	.25	.26	.12	.24	.22	.20	.17	.10
37	.16	.92	.30	.27	.28	.11	.32	.24	4.60	ND	(^c)

3a. Summary of plutonium concentrations in high volume offsite samples, 1971

Location	Concentration (fCi/m ³)							
	February-June 1971		July-December 1971		Totals for year			
	Maximum concentration single sample	Average	Maximum concentration single sample	Average	Average concentration	Percent of standards	Total number of samples	Number below detection limit
26	0.41	0.21	0.41	0.13	0.17	0.84	41	11
27	.44	.20	3.43	.24	.24	.21	35	5
28	.44	.19	.73	.25	.21	1.06	33	2
29	.68	.22	1.32	.29	.26	1.30	44	5
30	.50	.19	.43	.20	.19	.97	30	3
31	.64	.23	.59	.24	.24	1.18	43	2
32	4.28	.46	1.93	.22	.35	1.80	84	4
33	.63	.28	.83	.19	.23	1.16	44	4
34	.92	.26	.28	.16	.23	1.14	28	4
35	.43	.22	.66	.21	.22	1.08	37	5
36	.70	.25	.87	.18	.21	1.05	43	6
37	2.22	.41	4.64	.23	.34	1.70	32	6
Yearly summation							444	57
Total average					0.24	1.20		

^a This network of samplers began operation in February 1971.^b See figure 3.^c Air samplers inoperative due to pump failure.

ND, nondetectable.

Note: For averaging purposes, all samples below minimum detectable amounts (MDA) were assigned a fractional value (number of samples >MDA divided by total number analyses) of the appropriate MDA.

Applicable standard (soluble plutonium-239) is 20 fCi/m³.

gram are on the same order of magnitude as reported for worldwide fallout measurements (1). These levels represent no health or safety hazard. There is possibly some insignificant but nonetheless real contribution from Rocky Flats. Studies are now underway to determine what (if any) contribution is directly attributable to Rocky Flats.

Water samples

Rocky Flats is drained by three streams: North and South Walnut Creeks to the north

of the plant site, and Woman Creek to the south. For reference, North Walnut Creek is classified as the plant's "A" drainage, South Walnut Creek as the "B" drainage, and Woman Creek as the "C" drainage.

Sanitary and process waste waters are released after treatment to South Walnut Creek through a series of four holding ponds (ponds B-1, B-2, B-3, B-4). Effluents released through the sewage plant meet all water quality standards as established by the Colorado Department of Health (2) or the U.S. Public Health Service Drinking Water Standards Act (1962)

Table 4. Plutonium concentrations in special high-volume air samples, Rocky Flats Plant, January-December 1971

Location of grab samples	Concentration (fCi/m ³)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Onsite: ^a												
903-20.....	0.93	0.85	2.36	1.09	1.96	2.72	1.06	2.50	7.10	2.59	3.01	5.45
903-15.....	.55	1.38	4.15	1.30	.38	1.54	6.96	7.89	110.00	18.51	.41	.42
903-10.....	.91	1.43	4.03	.94	.50	1.24	.87	1.10	168.19	39.11	1.52	3.17
903-5.....	.46	1.02	.40	1.23	.79	21.16	.81	1.56	125.6	NS	4.31	2.63
Offsite:												
Wagner.....	.64	1.96	1.76	2.73	1.45	1.95	2.41	7.22	13.24	14.37	1.29	1.26
Coal Creek.....	NA	4.27	1.38	1.86	1.31	12.09	1.66	3.59	1.42	.38	1.17	2.83

4a. Yearly summation of plutonium concentrations in special high-volume air samples, RFP, January-December 1971

Location	Single sample maximum (fCi/m ³)	Average concentration (fCi/m ³)	Percent of standard ^{b, c}	Number of samples	Number less than detection limits
Onsite:					
903-20.....	18.00	2.4	4.0	49	13
903-15.....	408.40	14.676	24.5	49	20
903-10.....	516.40	22.319	37.2	50	16
903-5.....	49.60	3.371	5.6	41	14
Total (averages).....		11.5	19.1	189	63
Offsite:					
Wagner.....	49.50	3.438	17.2	44	10
Coal Creek.....	60.20	3.142	15.7	38	11
Total (averages).....		3.3	16.6	82	21

^a Onsite grab samples taken east of asphalt pad covering contaminated soil on plant site.

^b Standard for onsite samples is taken as 60 fCi/m³.

^c Offsite standard, 20 fCi/m³.

NA, no analysis.

(3). The overflow from the pond system (Ponds B-1 through B-4) flows into Great Western Reservoir.

Continuous flow into this reservoir is comprised mainly of liquid wastes from Rocky Flats and makes up a small portion of the drinking water for the community of Broomfield.

Holding ponds are also located on North Walnut Creek (Pond A) and on Woman Creek (Pond C), but no effluents are discharged directly into these holding ponds.

Daily water samples are collected from Pond B-4, and three times weekly from the Ponds A and C. These samples are composited into a weekly sample and analyzed for their gross alpha (uranium and plutonium) content as well as specifically for plutonium and for americium.

Tap water samples from the surrounding communities (Arvada, Boulder, Broomfield, Denver, Golden, Lafayette, Louisville, Thornton, and Westminster) and water samples from four reservoirs in the area are collected every 2 weeks, and analyzed specifically for gross alpha and plutonium. Standley and Great Western Reservoir water samples are also analyzed for americium.

Weekly grab samples are taken from Walnut Creek below the confluence of the North and South branches and analyzed for gross alpha and specifically for plutonium and americium content. As a further safeguard, nearly all waters in the immediate vicinity are surveyed semiannually and analyzed for gross alpha (uranium and plutonium) and for plutonium content. There are 34 such bodies of waters

Table 5. Plutonium in dustfall samples, 1971

Location	Number of samples	Number of samples less than detection limit	Sample days	Maximum (single sample) concentration (pCi/m ³)	Total deposition (pCi/m ²)	Deposition rate (pCi/m ² /month)
Arvada.....	23	9	362	16.11	76.45	6.35
Berthoud *.....	7	2	316	5.58	12.98	1.23
Broomfield.....	22	12	348	28.88	74.48	6.42
Boulder.....	22	14	334	28.59	85.69	7.70
Castle Rock *.....	9	7	355	2.46	6.46	.55
Coal Creek.....	20	12	306	21.66	51.26	5.02
Denver.....	23	11	341	53.87	118.27	10.41
Eastlake.....	23	11	362	10.59	49.84	4.13
Golden.....	22	9	348	^b 174.16	^b 219.55	^b 18.93
Lafayette.....	22	13	362	35.83	82.59	6.84
Marshall.....	22	11	362	67.70	149.04	12.85
Superior.....	21	8	334	16.11	74.20	6.68
Wagner.....	20	8	313	13.17	70.39	6.75
Westminster.....	23	9	362	^b 1127.11	^b 1163.50	^b 96.84

* Background samples.

^b Based on highly suspect data.

surveyed, 18 within 5 miles of the plant site and 16 at distances greater than 5 miles.

The most restrictive standard, that for soluble plutonium-239, is 1.67 nCi/liter in terms of yearly averages to a suitable sample of a population. Gross alpha concentrations in samples from B-4 pond had a maximum of 36.64 pCi/liter, and a yearly average of 11.79 pCi/liter. These gross alpha concentrations are contributions from both plutonium and uranium. All other naturally occurring long-lived alpha emitters are removed from the samples during the analytical procedure.

Total maximum plutonium concentration in pond B-4 was 7.23 pCi/liter with a yearly average of 1.89 pCi/liter. Americium-241 maximum was 3.07 pCi/liter with a yearly average of 1.12 pCi/liter.

Grab samples from Pond A showed a maximum gross alpha concentration of 28.89 pCi/liter, with a yearly average of 7.30 pCi/liter. Pond C showed similar low concentrations with a yearly maximum (gross alpha) of 23.64 pCi/liter and a yearly average of 6.14 pCi/liter.

Those grab samples taken at the confluence of North and South Walnut Creeks showed a maximum gross alpha of 56.05 pCi/liter. Maximum plutonium concentration found was 8.47 pCi/liter, and maximum americium was 1.67 pCi/liter. Average gross alpha was 12.17, average plutonium, 2.26 pCi/liter and average americium, 0.60 pCi/liter.

Tap water results averaged 3.32 pCi/liter for gross alpha radioactivity with a maximum of 18.58 pCi/liter gross alpha activity. Gross alpha concentrations in the reservoirs averaged 6.76 pCi/liter with a maximum individual measurement of 30.40 pCi/liter at Ralston Reservoir.

Average plutonium concentrations, summarized in tables 6-11 show that all water samples, from tap water, reservoirs, and holding ponds were 1 000 to 10 000 times less than the most restrictive standard for soluble plutonium.

Sediment samples

Sediment samples from the four major reservoirs are collected semiannually and more frequent sediment samples are taken from each of the six holding ponds. Additional samples are also taken from Walnut and Woman Creeks. These samples are taken to a depth of 4 centimeters. No specific standard now exists for plutonium in sediment samples. The results, tabulated in table 12, indicate a maximum of 641.67 pCi/g (dry weight) within the controlled area. The maximum concentration found outside the controlled access area of the plant site was 7 pCi/g.

Soil samples

The Rocky Flats Health Physics Department has maintained an extensive soil sampling program on a routine basis since mid-1969. Prior

Table 6. Radioactivity in holding pond B-4 (effluent wastewater), Rocky Flats Plant, January-December 1971

Month (1971)	Number of samples	Effluent volume (MI)	Uranium and plutonium			Plutonium			Americium		
			Concentration (pCi/liter)		Total release (mCi)	Concentration (pCi/liter)		Total release (mCi)	Concentration (pCi/liter)		Total release (mCi)
			Maxi- mum	Aver- age		Maxi- mum	Aver- age		Maxi- mum	Aver- age	
January.....	4	36.01	36.64	14.33	0.516	4.01	2.29	0.082	3.07	3.07	0.111
February.....	4	34.85	27.73	24.74	.862	7.23	2.92	.101	1.36	1.20	.042
March.....	4	49.18	19.29	18.15	.647	4.32	2.86	.141	2.67	1.89	.093
April.....	5	41.21	19.98	14.75	.608	5.23	2.99	.123	2.39	1.61	.066
May.....	4	32.32	19.06	12.54	.406	4.59	2.63	.085	2.26	.94	.030
June.....	5	28.15	10.30	8.33	.234	2.61	1.60	.045	2.18	1.37	.039
July.....	4	23.95	8.95	5.79	.139	6.09	3.20	.076	1.29	1.08	.025
August.....	4	30.47	18.75	11.34	.346	2.77	1.05	.032	.52	.42	.013
September.....	5	33.69	11.19	6.93	.233	2.04	1.29	.043	1.08	.65	.022
October.....	4	42.64	5.75	5.61	.239	1.59	1.01	.043	.14	.06	.003
November.....	4	47.61	16.08	10.67	.508	.98	.59	.028	1.80	.76	.036
December.....	5	53.79	18.59	11.48	.618	1.56	1.09	.059	NA	NA	NA

6a. 1971 summary of radioactivity in holding pond B-4 (effluent wastewater) Rocky Flats Plant

Month (1971)	Number of samples	Uranium and plutonium			Plutonium			Americium ^b		
		Concentration (pCi/liter)		Total release (mCi)	Concentration (pCi/liter)		Total release (mCi)	Concentration (pCi/liter)		Total release (mCi)
		Maxi- mum	Aver- age		Maxi- mum	Aver- age		Maxi- mum	Aver- age	
January-June.....	26	36.64	14.76	3.273	7.23	2.61	0.578	3.07	1.72	0.381
July-December.....	26	18.59	8.97	2.082	6.09	1.21	.282	1.29	.55	.127
Summary.....	52	36.34	11.79	5.355	7.23	1.89	0.860	3.07	1.12	0.508

^a Yearly summation pond B-4 (effluent wastewater: total volume 1971 = 453.91 MI).

^b July-December 1971 americium average calculated from 5-month data; July-December release = average concentration x July-December effluent; summary average = 0.508 divided by total effluent.

NA, no analysis.

Table 7. Radioactivity in holding ponds A and C, Rocky Flats Plant, January-December 1971

Month (1971)	Pond A				Pond C			
	Number of samples	Number of samples less than de- tectable level	Concentration (pCi/liter)		Number of samples	Number of samples less than de- tectable level	Concentration (pCi/liter)	
			Uranium and plutonium	Plutonium			Uranium and plutonium	Plutonium
January.....	4	0	7.07	0.51	4	0	6.98	0.26
February.....	4	0	8.88	.42	4	0	10.98	.72
March.....	4	0	7.09	.31	4	0	5.66	.25
April.....	5	0	6.62	1.12	5	0	6.44	1.13
May.....	4	0	6.25	.85	4	0	6.73	.81
June.....	5	0	4.63	1.21	5	0	4.52	.94
July.....	4	0	3.93	.97	4	0	4.19	.47
August.....	4	0	7.27	.66	4	0	8.63	.60
September.....	5	0	6.13	.51	5	0	6.90	.42
October.....	4	0	6.85	.32	4	0	4.32	.48
November.....	3	0	9.04	.38	4	0	3.80	.79
December.....	5	0	13.75	.79	5	0	4.47	.41

7a. 1971 summary of radioactivity in holding ponds A and C, Rocky Flats Plant

Location	Uranium and plutonium					Plutonium				
	Number of samples ^a	Concentrations (pCi/liter)			Percent of AEC standard ^b	Number of samples ^a	Concentrations (pCi/liter)			Percent of AEC standard ^c
		Maximum	Minimum	Average			Maximum	Minimum	Average	
Pond A-----	51	28.89	1.33	7.30	0.11	49	2.76	0.04	0.68	0.04
Pond B-----	51	23.64	0.82	6.14	0.09	52	3.84	0.06	0.58	0.03

^a The number of samples less than detectable limit for Ponds A and C in 1971 was 0.

^b Gross alpha standard is $\frac{C_U}{MPC_U} + \frac{C_{Pu}}{MPC_{Pu}} \leq 1$ where: MPC for uranium = 10 000 pCi/liter; MPC for plutonium = 1 667 pCi/liter.

^c The plutonium standard is 1 667 pCi/liter.

Table 8. Radioactivity in effluent waste water (Walnut Creek at Indiana Road), RFP, January-December 1971

Month (1971)	Uranium and plutonium				Plutonium				Americium			
	Number of samples	Concentration (pCi/liter)			Number of samples	Concentration (pCi/liter)			Number of samples	Concentration (pCi/liter)		
		Maximum	Minimum	Average		Maximum	Minimum	Average		Maximum	Minimum	Average
January-----	2	19.71	2.85	11.28	2	2.68	1.28	1.98	1	0.73	0.73	0.73
February-----	4	30.06	13.69	19.30	4	8.47	.86	4.36	3	1.67	.68	1.25
March-----	5	11.53	4.76	8.91	5	3.33	1.36	2.52	2	1.60	.70	1.15
April-----	4	13.68	6.32	11.18	4	3.10	1.14	2.09	3	.93	.49	.72
May-----	4	12.43	7.15	9.91	4	6.59	.67	2.68	2	.47	.40	.44
June-----	5	11.43	6.40	9.05	5	3.21	1.28	2.04	5	1.25	.30	.58
July-----	4	29.54	3.87	11.67	4	3.61	1.54	2.56	2	.80	.41	.61
August-----	5	36.58	3.73	13.16	5	3.14	1.03	1.65	5	.68	.30	.49
September-----	4	22.10	2.18	9.07	4	7.99	.08	2.41	4	.29	.01	.19
October-----	4	49.34	3.12	16.87	4	3.71	.41	1.96	2	.77	.21	.49
November-----	5	56.05	3.97	15.89	5	3.80	.67	1.64	5	1.05	.20	.46
December-----	3	12.81	5.77	8.96	3	1.33	.83	1.03	0	-----	-----	-----

8a. 1971 summary of radioactivity in effluent waste water (Walnut Creek at Indiana Road) RFP, January-December 1971

Month (1971)	Uranium and plutonium					Plutonium					Americium				
	Number of samples	Concentration (pCi/liter)			Percent of AEC standards ^a	Number of samples	Concentration (pCi/liter)			Percent of AEC standards ^b	Number of samples	Concentration (pCi/liter)			Percent of AEC standards ^c
		Maxi- mum	Mini- mum	Ave- rage			Maxi- mum	Mini- mum	Ave- rage			Maxi- mum	Mini- mum	Ave- rage	
January-June July-December	24 25	30.06 56.05	2.85 2.18	11.41 12.90	24 25	8.47 7.99	0.67 0.41	2.64 1.89	16 18	1.67 1.05	0.30 0.01	0.79 0.43			
Summary	4 49 (0)	56.05	2.18	12.17	0.23	4 49 (0)	8.47	0.41	2.26	0.14	4 34 (1)	1.67	0.01	0.60	0.05

^a The standard for a mixture of soluble uranium and plutonium in water is $\frac{C_U}{MPC_U} + \frac{C_{Pu}}{MPC_{Pu}} \leq 1$ where MPC_U = 10 000 pCi/liter and MPC_{Pu} = 1 667 pCi/liter.

^b Based on the soluble plutonium-239 in water standard of 1 667 pCi/liter.

^c Based on the soluble americium-241 in water standard of 1 333 pCi/liter.

^d () denotes less than detectable levels.

Table 9. Radioactivity in reservoir water samples, Rocky Flats, January-December 1971

Location	Uranium and plutonium			Plutonium			Americium		
	Number of samples	Concentration (pCi/liter)		Number of samples	Concentration (pCi/liter)		Number of samples	Concentration (pCi/liter)	
		Maximum	Average		Maximum	Average		Maximum	Average
January-June 1971:									
Baseline Reservoir	12	6.06	3.25	* 11 (0)	1.68	0.33			
Great Western Reservoir	12	6.29	3.12	12 (2)	.64	.14	4	1.13	0.60
Ralston Reservoir	12	30.40	20.50	10 (9)	2.53	.26			
Standley Reservoir	11	17.44	5.23	10 (0)	4.93	.76	1	.10	.10
July-December 1971:									
Baseline Reservoir	8	6.92	3.29	8	.46	.13			
Great Western Reservoir	12	16.06	3.70	12	.82	.26	8	.49	.13
Ralston Reservoir	12	22.04	10.22	9	.96	.20			
Standley Reservoir	11	6.05	3.17	11	.24	.09	4	.12	.06

9a. 1971 summary of radioactivity in reservoir water samples, Rocky Flats

Reservoir	Uranium and plutonium					Plutonium					Americium			
	Number of samples	Number of samples less than detectable limit	Maximum (pCi/liter)	Average (pCi/liter)	Percent of AEC standard ^b	Number of samples	Number of samples less than detectable limit	Maximum (pCi/liter)	Average (pCi/liter)	Percent of AEC ^a	Number of samples	Maximum (pCi/liter)	Average (pCi/liter)	Percent of AEC standard ^d
Baseline	20	0	6.92	3.27	0.05	19	3	1.68	0.25	0.02				
Great Western	24	1	16.06	3.41	.04	24	3	.82	.20	.01	12	1.13	0.29	0.02
Ralston	24	0	30.40	15.36	.17	19	12	2.53	.23	.01				
Standley	22	0	17.44	4.20	.06	19	4	4.93	.39	.02	5	.12	.07	.01
Summary	90	1	30.40	6.76	0.08	81	22	4.93	0.26	0.02	17	1.13	0.22	0.02

* () denotes number of samples less than detectable levels.

^b The standard for a mixture of soluble uranium and plutonium in water is $\frac{C_U}{MPC_U} + \frac{C_{Pu}}{MPC_{Pu}} \leq 1$ where $MPC_U = 10\ 000$ pCi/liter and $MPC_{Pu} = 1667$ pCi/liter.

^a Based on the soluble plutonium-239 in water standard of 1 667 pCi/liter.

^d Based on the soluble americium-241 in water standard of 1 333 pCi/liter.

to that time, samples were taken on a random basis and analyzed for gross alpha content. Although this gross alpha analysis would include plutonium and uranium as well as naturally occurring radionuclides, no specific plutonium analyses were routinely performed on these soil samples prior to that time.

The current program draws samples from a rough grid at 1, 2, and 5-mile distances from the center of the plant. About 75 locations, predominantly east and south of the plant site (corresponding to prevailing wind directions) but covering all areas between the perimeter and cattle fences, are sampled twice each year. In addition, locations along public right-of-way

also are sampled, and samples are taken from Denver, Arvada, Westminster, between Boulder and Fort Collins, between Leyden and Golden, along 104th Avenue and in Coal Creek Canyon. All samples are to a depth of 1 centimeter. In all, 159 soil samples were collected in 1971 and analyzed specifically for plutonium.

No specific standard has been set for plutonium in soils. The levels obtained in this sampling program are shown in figure 5.

All evidence gathered to date by the Rocky Flats Health Physics Department and other official agencies indicate that the plant has made some contribution to plutonium soil concentrations in the immediate vicinity of the

Table 10. Radioactivity in community tap water samples, RFP, January-December 1971

Location	Uranium and plutonium				Plutonium			
	Number of samples	Number of samples less than detectable level	Concentration (pCi/liter)		Number of samples	Number of samples less than detectable level	Concentration (pCi/liter)	
			Maximum	Average			Maximum	Average
Community tap water samples, January-June:								
Arvada.....	12	0	16.20	7.64	9	7	0.77	0.10
Boulder.....	12	0	6.93	2.32	9	0	.97	.32
Broomfield.....	12	0	18.58	2.54	6	0	*(5.03)	.98
Denver.....	12	0	17.19	5.73	11	2	2.79	.44
Golden.....	12	0	8.79	3.40	10	2	.45	.16
Lafayette.....	12	0	3.23	1.40	6	0	.77	.33
Louisville.....	12	0	2.45	1.25	4	0	.52	.28
Thornton.....	12	0	17.48	9.29	10	7	.90	.05
Westminster.....	12	0	6.49	2.26	11	1	1.80	.88
Radioactivity in reservoirs and tap water samples, July-December:								
Arvada.....	12	0	7.02	4.08	7	1	.78	.25
Boulder.....	12	0	8.62	1.66	10	5	.65	.17
Broomfield.....	12	0	9.00	2.84	9	3	.82	.25
Denver.....	12	0	5.77	2.89	9	3	2.03	.43
Golden.....	12	0	9.76	2.82	7	1	.47	.27
Lafayette.....	10	0	4.19	1.46	7	2	.82	.43
Louisville.....	11	0	3.15	1.31	7	1	1.60	.39
Thornton.....	11	0	8.60	4.88	6	1	.46	.21
Westminster.....	11	0	4.95	1.74	7	1	1.41	.43

10a. 1971 summary of radioactivity in community tap water samples, RFP

Location	Uranium and plutonium				Plutonium			
	Number of samples	Number of samples less than detectable level	Concentration (pCi/liter)		Number of samples	Number of samples less than detectable level	Concentration (pCi/liter)	
			Maximum	Average			Maximum	Average
Arvada.....	24	0	16.20	5.86	16	8	0.78	0.16
Boulder.....	24	0	8.62	1.99	19	5	.97	.24
Broomfield.....	24	0	18.58	2.69	15	3	*(5.03)	.54
Denver.....	24	0	17.19	4.31	20	5	2.79	.44
Golden.....	24	0	9.76	3.11	17	3	.47	.20
Lafayette.....	22	0	4.19	1.42	12	2	.82	.39
Louisville.....	23	0	3.15	1.27	11	1	1.60	.35
Thornton.....	23	0	17.48	7.18	16	8	.46	.11
Westminster.....	23	0	6.49	2.01	18	2	1.80	.40
Summary.....	211	0	18.58	3.32	144	37	(5.03)	0.31

* () denotes suspect data.

^b The standard for a mixture of soluble uranium+plutonium in water is $\frac{C_{Cu}}{MPC_{Cu}} + \frac{C_{Pu}}{MPC_{Pu}} \leq 1$ where MPC for uranium = 10 000 pCi/liter and MPC for plutonium = 1667 pCi/liter.

^c The standard for soluble plutonium-239 in water is 1 667 pCi/liter.

Note: For averaging purposes, all samples below minimum detectable amounts (MDA) were assigned a fractional value (number of samples > MDA divided by total number of analyses) of the appropriate MDA.

site. There is, however, no evidence to indicate that there has been any measurable or significant contribution to the Greater Denver metro

areas surrounding the plant. Nor is there any evidence that the levels found closer to the plant represent any health hazard.

Table 11. Semiannual water collection, RFP, 1971

Location	Concentration (pCi/liter)									
	Number of samples	Uranium + plutonium			Percent of standard ^a	Number of samples	Plutonium			Percent of standard ^d
		Minimum	Maximum	Average			Minimum	Maximum	Average	
<5 miles.....	28	0.54	16.35	2.72	0.05	13	0.05	2.76	0.41	0.02
>5 miles.....	32	.74	39.62	6.85	.08	16	.08	.92	.25	.01
Summary.....	60	0.55	39.62	4.92	0.07	29	0.05	2.76	0.32	0.02

* The standard for a soluble mixture of uranium+plutonium in water is $\frac{Cu}{MPCu} + \frac{Cpu}{MPCpu} \leq 1$ Where MPC for uranium is 10 000 pCi/liter and MPC for plutonium is 1 667 pCi/liter.

^b The standard for soluble plutonium-239 in water is 1667 pCi/liter.

Table 12. Plutonium radioactivity in sediment samples* RFP, January-December 1971

Location	Concentration (pCi/g dry weight)		
	Number of samples	Maximum	Average
Pond A.....	4	26.06	17.53
Pond B-1.....	3	641.67	319.87
Pond B-2.....	3	385.53	199.00
Pond B-3.....	3	174.85	67.99
Pond B-4.....	3	181.34	65.68
Pond C.....	3	8.47	3.35
Baseline Reservoir.....	2	7.03	3.68
Great Western Reservoir.....	2	1.87	1.08
Ralston Reservoir.....	2	.65	.43
Standley Lake.....	2	.42	.29

* Sample is top 4 centimeters of sediment.

Note: For averaging purposes, all samples below minimum detectable amounts (MDA) were assigned a fractional value (number of samples >MDA divided by total number of analyses) of appropriate MDA.

Vegetation samples

Vegetation samples are collected from 75 locations within a radius of 20 miles from the plant site. These are taken from public right-of-way twice each year, and are confined to those plants normally consumed by grazing domestic animals. The various samples are analyzed specifically for plutonium.

Results for 1971 (table 13) show that plutonium levels were a maximum of 3.00 pCi/g (dry weight). One notable aspect of this sampling program is that the plant is analyzed without any prior washing. Thus, the plant becomes a form of dustfall collector as well as a measurement of the amount of plutonium physically incorporated into the plant through normal growth activities. Although no specific stand-

ard has been established for plutonium in or on plants, these levels are considered by most experts to be insignificant, especially in light of empirically derived dilution factors (4).

No specific routine analyses are performed at Rocky Flats on food or biological samples. Rocky Flats has contracted with the Radiobiology Department of Colorado State University to make ecological studies of the flora and fauna in the immediate environs of the plant. This will be a continuing project.

Summary and conclusions

The principal protection for our environment must be provided at the very source of potential degradation and/or potential pollution. No program can replace adequate controls at the source: any environmental program is after the fact.

This is especially true for radioactive isotopes. Rocky Flats is working toward total containment of radioactive materials. The data contained in this report are the result of the controls employed at this plant site and do not in any way describe those complex controls in themselves. That these controls are effective can be seen by comparing releases with those established standards over the applicable time periods.

Following a fire at Rocky Flats in May 1969, intensified soil and monitoring surveys disclosed some soil contamination in the vicinity of the plant site, primarily to the east of the perimeter fence. Subsequent investigations in-

Table 13. Plutonium radioactivity in vegetation samples, RFP environs, June and September 1971

Location	June 1971				September 1971			
	Number of samples	Number of samples less than detectable limit	Concentrations (pCi/g dry weight)		Number of samples	Number of samples less than detectable limit	Concentrations (pCi/g dry weight)	
			Maximum	Average *			Maximum	Average
<1 mile---	20	5	2.5	0.29	22	8	3.0	0.18
1-5 miles---	38	7	.79	.12	39	11	.39	.054
>5 miles---	22	8	.25	.053	21	12	.17	.032
Summary---	80	20	2.5	0.14	82	31	3.0	0.082

* For averaging purposes, all samples below minimum detectable amounts (MDA) were assigned a fractional value (number of samples >MDA divided by total number of analyses) of the appropriate MDA.

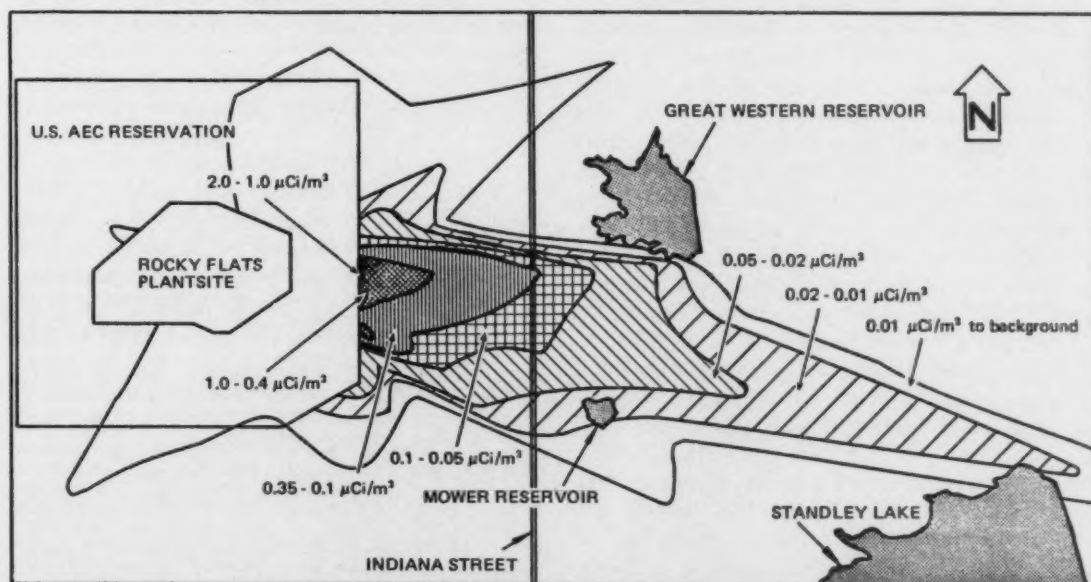


Figure 5. Surface soil analysis, offsite contours (These contours were empirically derived by means of a computer curve-fitting program using the method of least squares. This results in a mathematical expression for grid sectors, giving the activity of plutonium in the soil as a function of radial distance from the onsite barrel storage area. Three hundred and forty-two soil samples were used in generating these contours. Eighteen samples were taken by the Colorado Committee on Environmental Information, 18 by U.S. AEC Health and Safety Laboratory, 306 by the Rocky Flats Health Physics Department. The values assume a soil density of 1 g/cm³ at a depth of 1 centimeter.)

licated that no measurable radioactive contamination had escaped from the buildings involved in that fire, and that the primary source of contamination had come from waste drums of contaminated oil stored near the east

fence. Since it is felt that some resuspension of this material is inevitable, even though the most affected area is now covered with a thick asphalt pad, steps have been taken to reduce this possibility to an absolute minimum.

The affected areas are under constant surveillance. The contours in figure 5 have been empirically derived using the best data available from all sources, i.e., the U.S. AEC Health and Safety Laboratory and the Colorado Committee for Environmental Information, as well as the surveillance activities of the Rocky Flats Health Physics Department.

Rocky Flats is committed to a soil sampling program. This program requires that samples be taken more frequently. Constant evaluation of the data thus generated shows no significant change in the contours.

Dustfall samples taken from the surrounding area may well represent some of this contaminated material that has been resuspended. Wind in the vicinity of Rocky Flats could deposit very small quantities of this material in the Boulder, Golden, Marshall, and Coal Creek areas. Dustfall sampling in these areas indicate that this may very well be the case. There are, however, other factors that might be creating anomalies as great as or even greater than any contribution from Rocky Flats. Wind currents, sweeping down through Boulder and Coal Creek Canyons, and along the Front Range, could be depositing greater than to be expected concentrations of materials associated with worldwide fallout in these areas. It must be emphasized that these concentrations, even including any contributions from Rocky Flats, are still on the same order of magnitude as that to be expected from worldwide fallout (1) and, as such, provide no known health and/or safety hazard to the public. There is probably a very real contribution from Rocky Flats. This contribution is so low as to provide no significant exposure risk to the population in the area. Ways of reducing this contribution are, however, under intensive study. Total plutonium releases during 1971 by both stack effluent discharge and effluent water release were a total of 1.0 millicuries (0.016 grams). Total uranium releases, which include relatively high concentrations of naturally occurring isotopes, were about 5 millicuries.

Plutonium stack effluent releases from Rocky Flats have, on a single sample or single-month-maximum basis, exceeded both recommended guidelines, and especially internal plant goals

for limiting effluent concentrations. The same is true, although less frequently, for uranium releases. Although insignificant in terms of the yearly average concentrations, methods to limit and control those releases are being studied.

The primary reason for these higher-than-ordinary releases has been the system employed in changing filters in the exhaust plenums of process buildings. The time interval and the physical implementation of better techniques for these filter changes is under intensive study.

In summation, then, while Rocky Flats has met and mostly surpassed its goals for maintaining radioactive effluent emissions below the most restrictive standards available, to do even better is the implicit goal of the entire operation.

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Recent coverage in *Radiation Data and Reports*:

<u>Period</u>	<u>Issue</u>
1970	April 1973

2. Sandia Laboratories³
January-December 1971

*Environmental Health Department⁴
Albuquerque, N. Mex.*

Sandia Laboratories began as the Albuquerque branch of Los Alamos Scientific Laboratory after World War II and eventually became an independent engineering and research facility operated for the Atomic Energy Commission by the Bell System on a nonprofit basis. Although the laboratories are only a quarter-century old, they have already contributed significantly new capability and understanding in such areas as high temperature-resistant materials, micro-circuitry and miniaturization, active ceramics, telemetry, high-speed photography, and environmental testing.

As part of the environmental testing capability, Sandia Laboratories operates two research nuclear reactors at the SPRF-SERF site in technical areas 3 and 5, (figure 6) located approximately 6 miles south of Albuquerque, N. Mex. Located on a mesa, the SPRF-SERF site is bounded topographically on the west by the Rio Grande, on the north by Tijeras Arroyo-Canyon, on the south by Hell's Canyon Wash, and on the east by the Manzano Mountains (figure 6).

The climate of the area is termed arid continental. Half the 8-inch average annual rainfall occurs during July to September, with the winter months being very dry. Temperature ranges are large, but extreme temperatures such as 0°F or 100°F are infrequent. Wind activity occurs mostly during the late winter and early spring months. On less than 13 percent of the days during the year does the maximum wind velocity reach 30 miles per hour.

The water table at the SPRF-SERF site is about 450 feet below the surface of the site. Indications are that ground water beneath the

site moves from east to west towards the Rio Grande.

Sandia Laboratories, Albuquerque has conducted an environmental monitoring program since 1959 (5). The calendar year 1971 data are presented and discussed in this report.

Sample type and frequency

Soil and vegetation samples are collected annually at the 20 sites shown on figure 6. Vegetation samples are collected at the end of the growing season when plant uptake would be maximum. Deep well (approximately 1000 feet deep) water samples are collected quarterly from whichever of 8 portable water wells on Sandia base that are in use when the samples are taken (27 well water samples were taken in 1971).

All the above samples are analyzed for only gross beta, unless a high result is noted; in the event of such a high gross beta result, re-sampling is done and analyses are performed for strontium-90 and/or cesium-137.

Four additional soil sites, shown on figure 6, are sampled annually and the soil is analyzed for either gross alpha or total plutonium. These samples are for background data only, since Sandia Laboratories, Albuquerque currently handles plutonium only as sealed sources.

Sampling technique

Water—A 2-liter sample is taken in an acid-cleaned and distilled-water-rinsed plastic jug from the well head before any water treatment for human consumption.

Soil—Soil is collected from an area 1 foot square by 1 inch deep in a vegetation-free area and placed in a labelled plastic bag until analysis.

Vegetation—Available grass characteristic of the sampling site is collected in such a manner that no roots or soil contaminate the sample. The amount taken is about 500 grams and it is stored in plastic bags with air holes to prevent decomposition before analysis.

Methods of analysis

Water samples are shaken thoroughly when filtered, separating dissolved and suspended

³ Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission, Sandia Laboratories, 1971."

⁴ An AEC-owned facility operated for the U.S. Atomic Energy Commission by Sandia Corporation under Contract AT(29-1)-789.

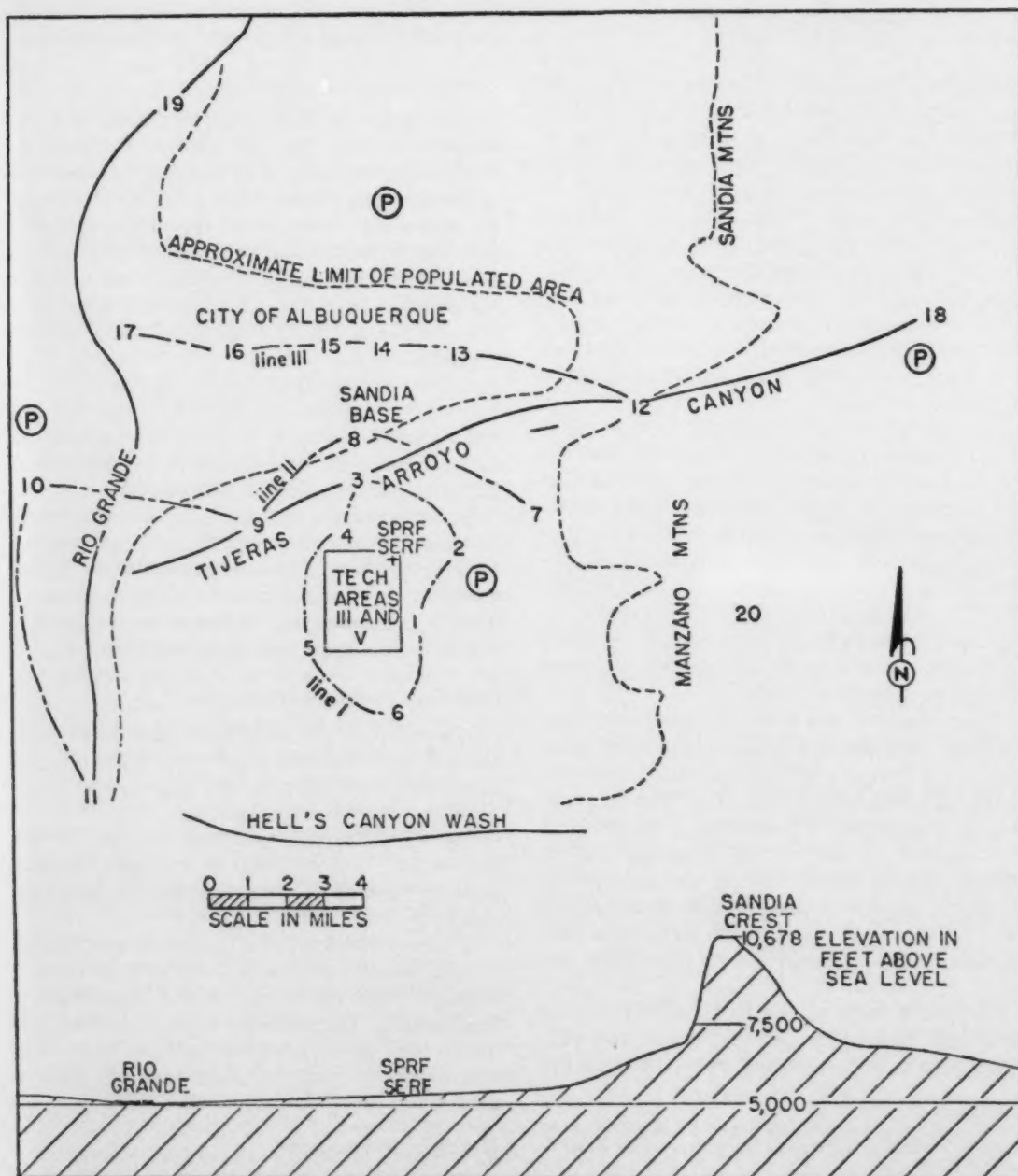


Figure 6. Salient topography of Area 5 and site locations, Sandia Laboratories

solids. Hardness of the water is determined so that no more than 7 mg/cm² of solids will be in the final deposit. Water is filtered through a hydrosol type membrane filter (0.45 μ m). Filtered water is acidified with nitric acid and evaporated to a small volume which is transferred to a 2-inch tared stainless-steel planchet. The water then is evaporated to dryness, reweighed and beta counted.

The membrane filter is transferred to a 2-inch tared stainless-steel planchet, with solids down against planchet, the filter is dissolved in acetone, then excess acetone burned off. The planchet is reweighed and beta counted. The results of the water analyses are presented in table 14.

Table 14. Gross beta radioactivity in well water Sandia Laboratories, 1971

	Well water concentration (pCi/liter)
Dissolved solids (average).....	2.81
Suspended solids (average).....	.46
Total coverage.....	3.27
Most restrictive AEC standard.....	30
Percent of total gross beta in well water to standard.....	10.9

Water containing the cesium is passed through a KCFC⁵ ion exchange column. The resin containing the cesium is gamma counted for cesium-137 (6).

Radiostromium, calcium, barium, radium, and rare earth nuclides are precipitated from the water as oxalates. The calcium, barium, radium, and rare earth nuclides in the precipitate are separated as soluble nitrates from the strontium. The radiostromium is allowed to sit for 15 days for the radioyttrium to grow in before counting (7).

Soil samples are mixed thoroughly, quartered if needed, then dried at 90°C overnight. The sample then is ground to pass a 200 mesh sieve. This fine powder is used for analysis.

Pretreated soil is reacted with HF to remove silica and then fused with sodium pyrosulfate. The fusion mixture is dissolved in HCl and diluted to a known volume with water. An aliquot is evaporated to dryness on a planchet and alpha counted.

The acid solution from the gross alpha determination is adjusted to 8M HCl. A tracer plutonium-236 is added and the plutonium is separated on an ion exchange resin. The plutonium is removed from the resin, electro-deposited and quantitated by alpha spectrometry (8).

Vegetation samples are mixed thoroughly, cut into small pieces (using a blender), ashed at 450°C, and the ash is used for analysis. Vegetation ash is treated with nitric acid to remove the beta activity, filtered, and the filtrate is planchettied for gross beta counting (7). The results of the soil and vegetation analyses are presented in table 15.

A 5 gram sample of pretreated soil or vegetation ash is fused with sodium carbonate. The fusion mixture is dissolved in water and acidified with nitric acid, and the cesium is collected on an ion exchange column (KCFC).⁵ The resin containing the cesium is then gamma counted for cesium-137 (8).

To a 5 gram sample of pretreated soil or vegetation ash, barium and strontium carriers are added followed by concentrated nitric acid. The sample is digested and then evaporated to dryness. An oxalate precipitation followed by a nitrate precipitation of strontium is made. The strontium-90 is determined by allowing the yttrium to grow in for 15 days, and then the sample is beta counted (7).

Table 15. Gross beta radioactivity in soil and vegetation Sandia Laboratory, 1971

Sample sites ^a	Soil ^b (pCi/g dry weight)	Vegetation ^c (pCi/g ash weight)
1-6.....	40.0 \pm 2.9	171
7-11.....	2.8 \pm 3.4	173
12-17.....	3.4 \pm 3.4	139
18-20.....	1.9 \pm 3.2	201

^a See figure 6.

^b All four samples analyzed for plutonium were below the detection limit of 3 pCi/g of dried soil.

^c Vegetation was ashed at 450°C, before analysis. Ratio of wet weight to ash weight is about 12.

^d Error limits are counting errors at the 95-percent confidence level.

⁵ KCFC, an inorganic ion exchange resin—potassium hexacyanocobalt (II) ferrate (II).

Summary

The environmental monitoring program conducted during 1971 showed that none of the samples of soil, vegetation, or well water taken near the nuclear reactor site in areas 3 and 5 contained radioactivity that was statistically different from the current background radioactivity in Albuquerque. We conclude that no health or environmental quality problem exists in Albuquerque as a result of any Sandia Laboratories facility operation.

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3. Stanford Linear Accelerator Center^a January-December 1971

*Stanford Campus
San Mateo County, California*

The Stanford Linear Accelerator Center (SLAC) is located 2 miles west of the Stanford Campus in San Mateo County, California. Its boundaries include Sand Hill Road on the north and San Francisquito Creek on the south. The land slopes to the south toward San Francisquito Creek. The total length of the accelerator and experimental areas is approximately 3 miles and is oriented almost east-west. Figure 7 shows SLAC with respect to the surrounding vicinity.

The SLAC regional surveillance program is intended to assess the contribution from

^a Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission, Stanford Linear Acceleration Center, 1971."

SLAC operations, if any, to the existing radiation environment. Accordingly, samples of soil, vegetation, ground water, surface water, sanitary and storm sewers periodically are collected and activity levels determined. Continuous physical radiation measurements of neutron and gamma dose also is provided. Environmental and physical radiation monitoring locations are indicated in figure 8.

Environmental samples

There has been no evidence of increased radioactivity in environmental water, soil and vegetation samples collected and analyzed for gross beta and tritium activity during 1971. The level of radioactivity is comparable to pre-operational levels and does not reflect any measurable change attributable to SLAC operations. Table 16 summarizes the gross beta activity found in environmental samples collected at SLAC. Tritium is not reported because all water samples contained less than the minimum detectable concentration of 3 nCi/liter.

During 1971, SLAC released 5.2 Ci of short-lived gases (¹⁵O, ¹³N, ¹¹C, and ⁴¹Ar) to the atmosphere. This quantity represents <1 percent of the amount that could produce, beyond SLAC's boundaries, a concentration of 40 nCi/m³ averaged over a 12-month period.

Table 16. Measured radioactivity in environmental samples
Stanford Linear Accelerator Center, 1971

Sample type	Number of samples	Range of gross beta radioactivity results ^a
Well water (pCi/liter)-----	64	18-100
Surface water (pCi/liter)-----	4	1- 23
Stream silt as soil (pCi/g)-----	2	32- 36
Vegetation (pCi/g)-----	2	31- 36

^a Includes potassium-40 radioactivity.

Table 17. Annual dose measured at peripheral monitoring stations, Stanford Linear Accelerator Center, 1971

Station	Gamma and neutron ^a dose (mrem)
1-----	110 (104)
2-----	81 (88)
3-----	80 (68)
4-----	92 (70)
5-----	115 (100)
6-----	82 (100)
8-----	90 (86)

^a Value includes background radiation, number in parenthesis indicate annual background measurement at each station from 1968 data.

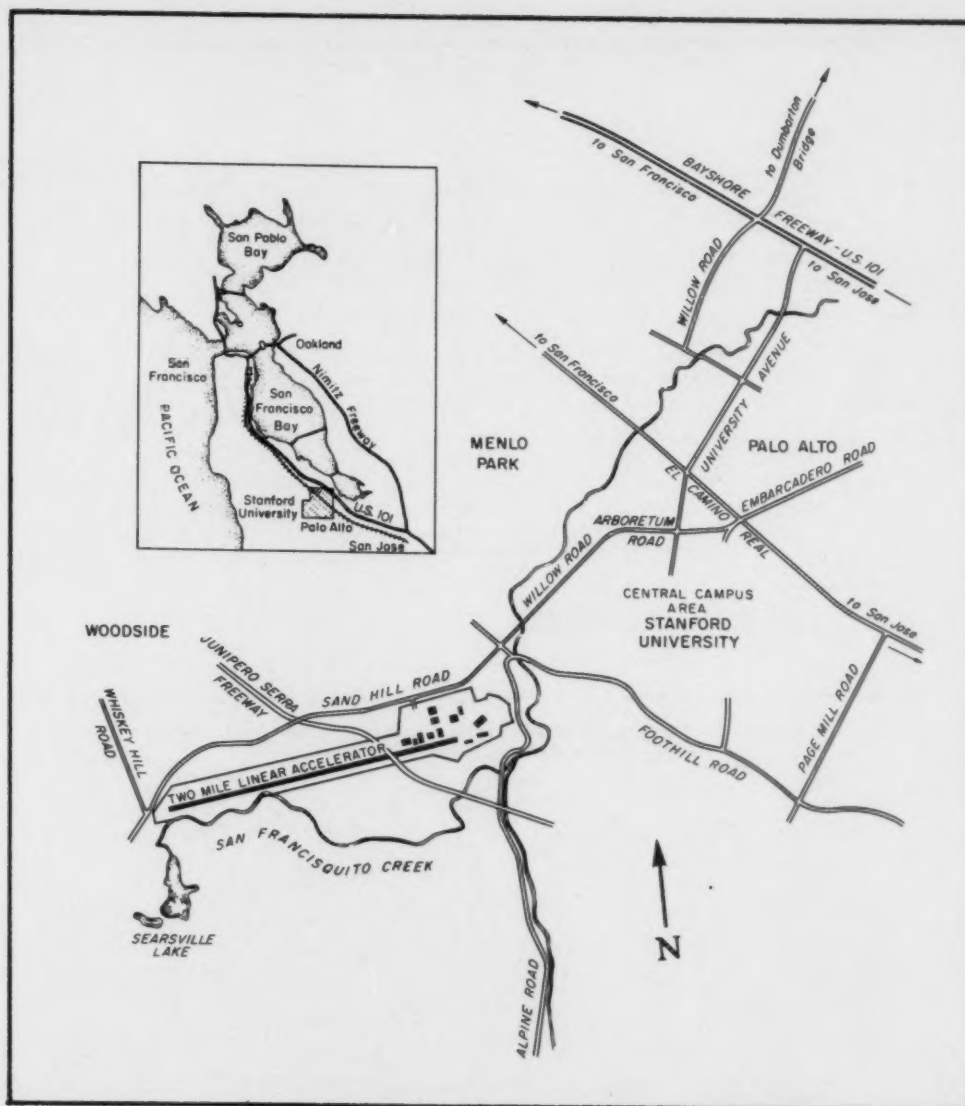


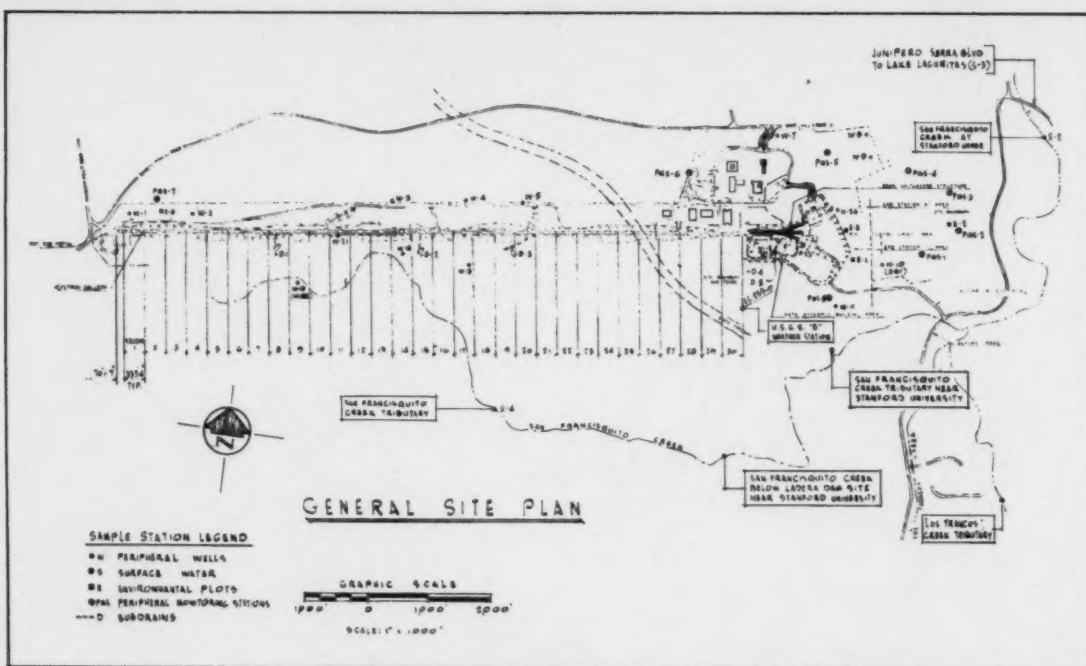
Figure 7. Site location relative to Stanford University and surrounding communities

Radiation measurements

Physical radiation measurements, near SLAC's boundaries, which include gamma and neutron radiation levels caused by skyshine, are summarized in table 17 and include background radiation response. Preoperational measurements of background radiation at SLAC and measurements made during periods

when the accelerator was not operating indicate a total annual dose of 110 ± 20 mrem averaged over the seven operation stations.

From these measurements it can be concluded that, only one station recorded a small increase over background which is <5 percent of the permissible annual individual dose at the site boundary.



**Figure 8. Environmental and physical radiation monitoring locations
Stanford Linear Accelerator Center**

Nuclear Power Reactors in the United States **March 31, 1974**

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports*.

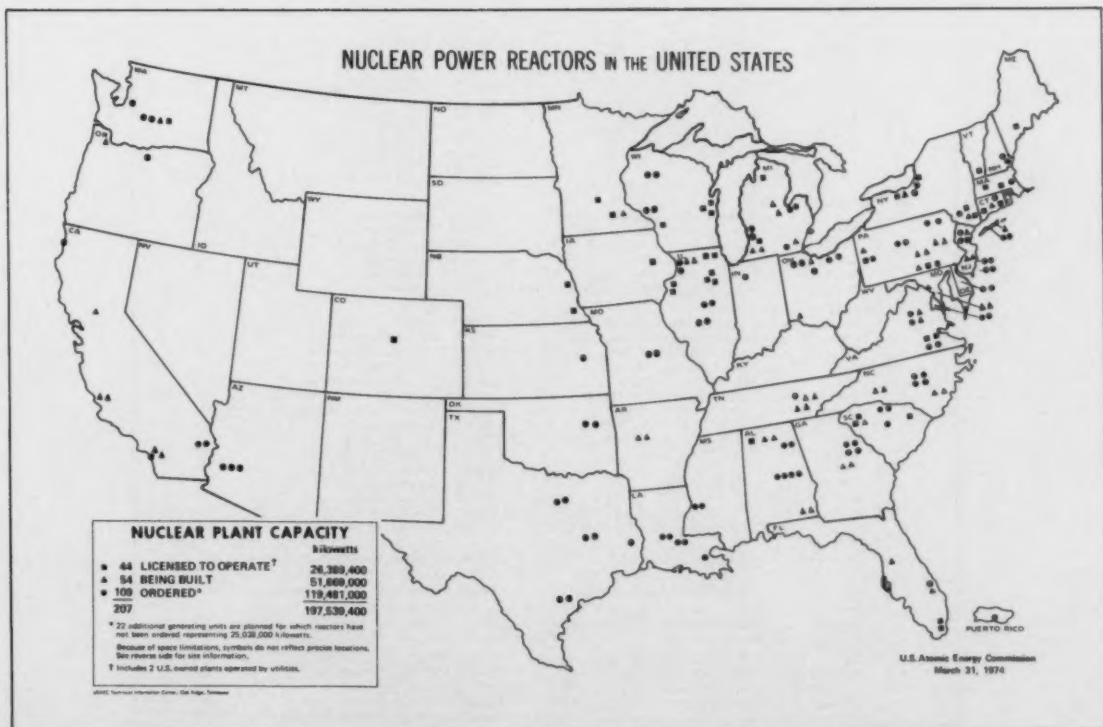


Figure 1. Nuclear power reactors in the United States, March 31, 1974

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1975
Dothan	Joseph M. Forley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Forley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
Chilton County	Central Alabama Nuclear Plant: Unit 1	1,200,000	Alabama Power Co.	1982
Chilton County	Central Alabama Nuclear Plant: Unit 2	1,200,000	Alabama Power Co.	1983
Elmore County	Central Alabama Nuclear Plant: Unit 3	1,200,000	Alabama Power Co.	1984
Elmore County	Central Alabama Nuclear Plant: Unit 4	1,200,000	Alabama Power Co.	1985
Scottsboro	Belleville Nuclear Plant: Unit 1	1,189,000	Tennessee Valley Authority	1979
Scottsboro	Belleville Nuclear Plant: Unit 2	1,189,000	Tennessee Valley Authority	1980
ARIZONA				
Wintersburg	Palo Verde Nuclear Generating Station: Unit 1	1,270,000	Arizona Public Service	1981
Wintersburg	Palo Verde Nuclear Generating Station: Unit 2	1,270,000	Arizona Public Service	1982
Wintersburg	Palo Verde Nuclear Generating Station: Unit 3	1,270,000	Arizona Public Service	1984
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	850,000	Arkansas Power & Light Co.	1974
Russellville	Arkansas Nuclear One: Unit 2	912,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	65,000	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1968
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1975
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1980
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,084,000	Pacific Gas and Electric Co.	1975
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,106,000	Pacific Gas and Electric Co.	1976
Clay Station	Rancho Seco Nuclear Generating Station	913,000	Sacramento Municipal Utility District	1974
*	-	1,128,000	Pacific Gas & Electric Co.	1981
*	-	1,128,000	Pacific Gas & Electric Co.	1982
Vidal	Vidal Generating Station: Unit 1	770,000	Southern California Edison Co.	1981
Vidal	Vidal Generating Station: Unit 2	770,000	Southern California Edison Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1974
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1968
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1971
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
Waterford	Millstone Nuclear Power Station: Unit 3	1,150,000	Northeast Utilities	1979
DELAWARE				
Summit	Summit Power Station: Unit 1	770,000	Delmarva Power & Light Co.	1980
Summit	Summit Power Station: Unit 2	770,000	Delmarva Power & Light Co.	1982
FLORIDA				
Florida City	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Florida City	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Rd Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1974
Ft. Pierce	St. Lucie Plant: Unit 1	801,000	Florida Power & Light Co.	1975
Ft. Pierce	St. Lucie Plant: Unit 2	801,000	Florida Power & Light Co.	1979
*	-	1,300,000	Florida Power Corp.	1983
*	-	1,300,000	Florida Power Corp.	1986
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1974
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	795,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,121,000	Georgia Power Co.	1980
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,121,000	Georgia Power Co.	1981
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 3	1,121,000	Georgia Power Co.	1982
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 4	1,121,000	Georgia Power Co.	1983
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1973
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1974
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle County Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1978
Seneca	LaSalle County Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1979
Bryon	Byron Station: Unit 1	1,120,000	Comm. Edison Co.	1980
Bryon	Byron Station: Unit 2	1,120,000	Comm. Edison Co.	1981
Braidwood	Braidwood: Unit 1	1,200,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 2	1,200,000	Comm. Edison Co.	1981
Clinton	Clinton Nuclear Power Plant: Unit 1	955,000	Illinois Power Co.	1980
Clinton	Clinton Nuclear Power Plant: Unit 2	955,000	Illinois Power Co.	1982
INDIANA				
Porter County	Billy Generating Station	980,000	Northern Indiana Public Service Co.	1979
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	560,000	Iowa Electric Light and Power Co.	1974
KANSAS				
Burlington	Wolf Creek Generation Station: Unit 1	1,150,000	Kansas Gas & Electric-Kansas City P & L	1981
LOUISIANA				
Taft	Waterford Generating Station	1,113,000	Louisiana Power & Light Co.	1977
St. Francisville	River Bend Station: Unit 1	934,000	Gulf States Utilities Co.	1980
St. Francisville	River Bend Station: Unit 2	934,000	Gulf States Utilities Co.	1981
St. Rose	-	1,200,000	Louisiana Power & Light Co.	1982
St. Rose	-	1,200,000	Louisiana Power & Light Co.	1984

Figure 1. Nuclear power reactors in the United States, March 31, 1974—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1974
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1975
Nanjemoy	Douglas Point Project: Unit 1	1,178,000	Potomac Electric Power Co.	1980
Nanjemoy	Douglas Point Project: Unit 2	1,178,000	Potomac Electric Power Co.	1981
MASSACHUSETTS				
Rose	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	664,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1980
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	75,000	Consumers Power Co.	1965
Smith Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,172,000	Detroit Edison Co.	1981
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1974
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1976
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1980
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1979
St. Clair County	Greenwood: Unit 2	1,200,000	Detroit Edison Co.	1980
St. Clair County	Greenwood: Unit 3	1,200,000	Detroit Edison Co.	1981
Quinacasser	Quinacasser: Unit 1	1,150,000	Consumers Power Co.	1981
Quinacasser	Quinacasser: Unit 2	1,150,000	Consumers Power Co.	1982
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1973
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSOURI				
Fulton	Callaway Plant: Unit 1	1,150,000	Union Electric Co.	1981
Fulton	Callaway Plant: Unit 2	1,150,000	Union Electric Co.	1983
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station: Unit 1	1,290,000	Mississippi Power & Light Co.	1979
Port Gibson	Grand Gulf Nuclear Station: Unit 2	1,290,000	Mississippi Power & Light Co.	1981
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownsville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1974
NEW HAMPSHIRE				
Seabrook	Seabrook Nuclear Station: Unit 1	1,200,000	Public Service of N.H.	1979
Seabrook	Seabrook Nuclear Station: Unit 2	1,200,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	840,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1979
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1975
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1976
Salem	Hope Creek Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1981
Salem	Hope Creek Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1982
Little Egg Inlet	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1980
Little Egg Inlet	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1981
"	"	1,150,000	Public Service Electric and Gas, N.J.	1983
"	"	1,150,000	Public Service Electric and Gas, N.J.	1984
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1962
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1973
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1969
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R.E. Ginna Nuclear Power Plant: Unit 1	490,000	Westchester Gas & Electric Co.	1970
Brookhaven	Bloomfield Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
Jamesport	"	1,150,000	Long Island Lighting Co.	1981
Jamesport	"	1,150,000	Long Island Lighting Co.	1983
Dowagong	Starling Nuclear: Unit 1	1,150,000	Rochester Gas & Electric Co.	1982
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowart Ford Dam	Wm. S. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1976
Cowart Ford Dam	Wm. S. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1980
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1981
Davie County	Perkins Nuclear Station: Unit 1	1,280,000	Duke Power Co.	1981
Davie County	Perkins Nuclear Station: Unit 2	1,280,000	Duke Power Co.	1982
Davie County	Perkins Nuclear Station: Unit 3	1,280,000	Duke Power Co.	1982
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 1	906,000	Toledo Edison-Cleveland El. Illum. Co.	1976
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 2	906,000	Toledo Edison-Cleveland El. Illum. Co.	1981
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 3	906,000	Toledo Edison-Cleveland El. Illum. Co.	1983
Perry	Perry Nuclear Power Plant: Unit 1	1,205,000	Cleveland Electric Illuminating Co.	1979
Perry	Perry Nuclear Power Plant: Unit 2	1,205,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1977
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 2	1,170,000	Cincinnati Gas & Electric Co.	1982

Figure 1. Nuclear power reactors in the United States, March 31, 1974—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
OKLAHOMA				
Inola	Black Fox Nuclear Station: Unit 1	950,000	Public Service of Oklahoma	1982
Inola	Black Fox Nuclear Station: Unit 2	950,000	Public Service of Oklahoma	1984
OREGON				
Pracott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1975
Boardman	Boardman 1	1,200,000	Portland General Electric Co.	1980
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1974
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pittstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1979
Pittstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1980
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	852,000	Duquesne Light Co.-Ohio Edison Co.	1975
Shippingport	Beaver Valley Power Station: Unit 2	852,000	Duquesne Light Co.-Ohio Edison Co.	1979
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1974
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Metropolitan Edison Co.	1975
Berwick	Susquehanna Steam Electric Station: Unit 1	1,050,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,050,000	Pennsylvania Power and Light	1981
Fuller	Fulton Generating Station: Unit 1	1,140,000	Philadelphia Electric Co.	1981
Fuller	Fulton Generating Station: Unit 2	1,140,000	Philadelphia Electric Co.	1983
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1974
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1978
Lake Wylie	Catawba Nuclear Station: Unit 1	1,153,000	Duke Power Co.	1979
Lake Wylie	Catawba Nuclear Station: Unit 2	1,153,000	Duke Power Co.	1980
Cherokee County	Cherokee Nuclear Station: Unit 1	1,280,000	Duke Power Co.	1982
Cherokee County	Cherokee Nuclear Station: Unit 2	1,280,000	Duke Power Co.	1983
Cherokee County	Cherokee Nuclear Station: Unit 3	1,280,000	Duke Power Co.	1984
TENNESSEE				
Davy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1975
Davy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1976
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1978
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1978
Oak Ridge	Clinch River Breeder Reactor Plant	350,000	U.S. Government	1980
TEXAS				
Glen Rose	Comanche Peak Steam Electric Station: Unit 1	1,150,000	Texas Utilities Services Inc.	1980
Glen Rose	Comanche Peak Steam Electric Station: Unit 2	1,150,000	Texas Utilities Services Inc.	1982
Jasper	Blue Hills: Unit 1	918,000	Gulf States Utilities	1980
Wallis	Allens Creek: Unit 1	1,150,000	Houston Lighting & Power Co.	1980
Wallis	Allens Creek: Unit 2	1,150,000	Houston Lighting & Power Co.	1982
Matagorda County	South Texas Project	1,250,000	Central Power & Light Co.	1980
Matagorda County	South Texas Project	1,250,000	Central Power & Light Co.	1982
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	898,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 2	898,000	Virginia Electric & Power Co.	1976
Mineral	North Anna Power Station: Unit 3	907,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	907,000	Virginia Electric & Power Co.	1978
Gravel Neck	Surry Power Station: Unit 3	882,000	Virginia Electric & Power Company	1980
Gravel Neck	Surry Power Station: Unit 4	882,000	Virginia Electric & Power Company	1981
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	850,000	Atomic Energy Commission	1966
Richland	WPPSS No. 1	1,206,000	Washington Public Power Supply System	1980
Richland	WPPSS No. 2	1,103,000	Washington Public Power Supply System	1977
Garney	WPPSS No. 3	1,242,000	Washington Public Power Supply System	1981
Sedro Woolley	Skagit Nuclear Project	1,206,000	Puget Sound Power & Light	1982
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	50,000	Dairyland Power Cooperative	1971
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1973
"	"	900,000	Wisconsin Electric Power Co.	1980
"	"	900,000	Wisconsin Electric Power Co.	1982
Durand	Tyrone Energy Park: Unit 1	1,150,000	Northern States Power Co.	1982
Durand	Tyrone Energy Park: Unit 2	1,150,000	Northern States Power Co.	1983
PUERTO RICO				
Puerto De Jolas	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1979
* Site not selected.				
"	"	1,228,000	Tennessee Valley Authority	1980
"	"	1,228,000	Tennessee Valley Authority	1981
"	"	1,228,000	Tennessee Valley Authority	1980
"	"	1,228,000	Tennessee Valley Authority	1981

Figure 1. Nuclear power reactors in the United States, March 31, 1974—continued

Reported Nuclear Detonations, April 1974

(Includes seismic signals presumably from foreign nuclear detonations)

There were no reported nuclear detonations for the United States for April 1974 and no recorded seismic signals for this month.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.



SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

ENVIRONMENTAL AND RADIOLOGICAL MONITORING AT THE NATIONAL REACTOR TESTING STATION DURING FY-1973 (July 1972-June 1973). *O. Doyle Markham. Radiation Data and Reports, Vol. 15, May 1974, pp. 227-246*

The routine environmental monitoring program at the National Reactor Testing Station (NRTS) during FY-1973 is described. In addition to the measurement of direct radiation exposures in the environment, the concentrations of radioactivity in air, groundwater, and milk also are determined. The results of the soil sampling program are discussed. The data from onsite and nearby community sampling locations are compared to background concentrations and the applicable standards established by the U.S. Atomic Energy Commission.

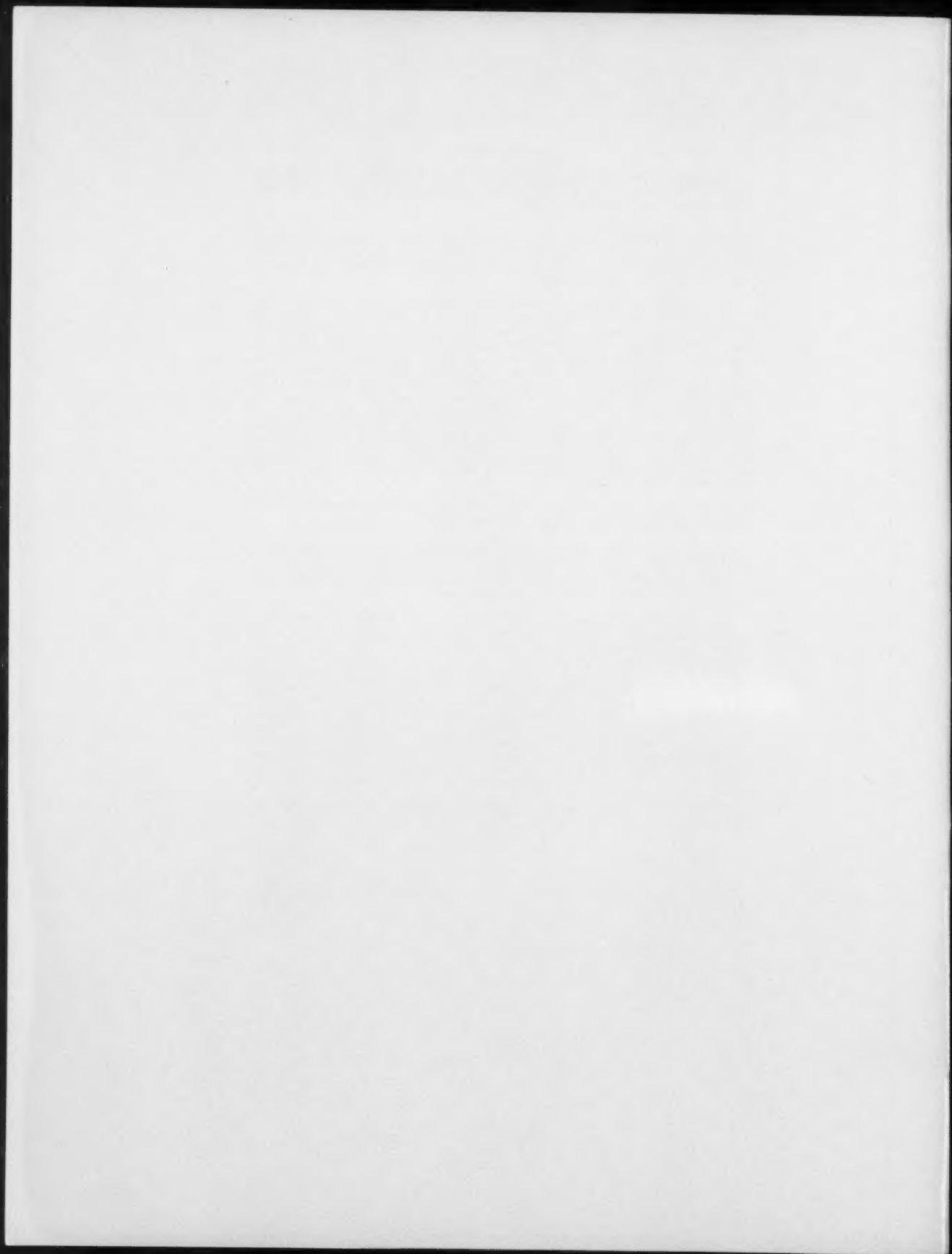
In addition, several special ecological monitoring programs have been designed to assess the effect of NRTS operations on the environment. One of the ecological studies quantifies the level of radioactivity in antelope tissues collected on and near the NRTS. An investigation to ascertain the ratio of iodine-129 to stable iodine-127 in the NRTS environs also is described.

KEYWORDS: air, antelope, ecological studies, groundwater, iodine, milk, National Reactor Testing Station, soil.

PERSONNEL AND ENVIRONMENTAL THERMOLUMINESCENT DOSIMETRY FOR A UNIVERSITY REACTOR LOCATED IN A SEMITROPICAL AREA. *P. S. Weng and C. Y. Huan. Radiation Data and Reports. Vol. 15, May 1974, pp. 247-252*

The LiF-Teflon discs were added to the film badges for personnel monitoring during a 6-month period. The results showed a consistently higher dose in the thermoluminescent dosimeter than in the photographic film dosimeter, which might exhibit about 90 percent fading during the 4-week monitoring period in a hot and humid climate. In winter time it was found that the response from both LiF-Teflon disc and film showed more consistent results due to better climate conditions in Taiwan. The $\text{CaSO}_4:\text{Dy}$ and $\text{CaSO}_4:\text{Tm}$ phosphor powders and $\text{LiF}:\text{Mg, Ti}$, enclosed in a knot of bamboo stick, were used for environmental monitoring at a university reactor site and inside a research reactor building. The results showed that they were unaffected by extremes of humidity and environmental temperatures in area monitoring, either indoors or outdoors.

KEYWORDS: Film badge, reactor, Taiwan, thermoluminescent dosimeter.



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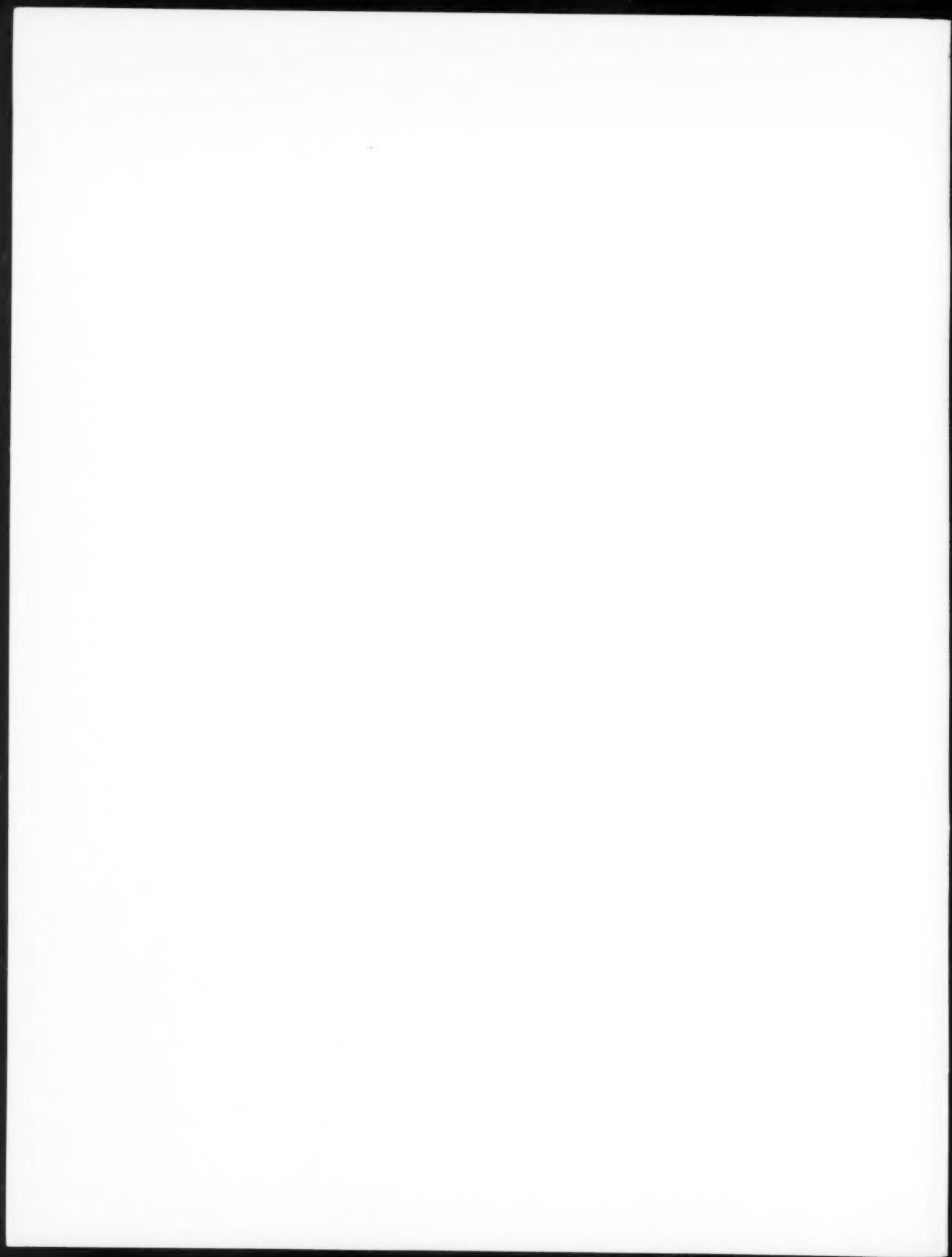
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May 1974



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